DOCUMENT RESUME

ED 241 302 SE 043 995

AUTHOR	Blosser, Patricia E., Ed.; Helgeson, Stanley L., Ed.
TITLE	National Association for Research in Science Teaching Annual Conference, Abstracts of Presented Papers (57th, New Orleans, Louisiana, April 28-30, 1984).
INSTITUTION	ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.
PUB DATE	31 Dec 83
CONTRACT	400-78-0004
NOTE	158p.
AVAILABLE FROM	ERIC/SMEAC, The Ohio State University, 1200 Chambers Rd., Room 310, Columbus, OH 43212 ($5.50).
PUB TYPE	Collected Works - Conference Proceedings (021) -- Information Analyses - ERIC Information Analysis Products (071)
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	*Academic Achievement; *Cognitive Development; Cognitive Processes; Curriculum Development; Elementary Secondary Education; Higher Education; Microcomputers; Process Education; Research Methodology; Science Curriculum; *Science Education; *Science Instruction; *Student Characteristics; Teacher Characteristics; *Teacher Education
IDENTIFIERS	*Science Education Research

ABSTRACT

Abstracts of most of the papers presented at the 57th Annual Meeting of the National Association for Research in Science Teaching (NARST) have been collected in this publication. Papers focus on such areas as cognitive structure, development of scientific literacy in secondary schools, science teaching as a career, improving science teaching, factors influencing attitudes toward science, teacher characteristics and student performance, intellectual development, concept learning, factors influencing achievement, test construction, science instruction, learning science in out-of-school settings, changing and assessing teacher attitudes, and research methods. Other papers focus on areas dealing with learning in chemistry, science teaching in higher education, microcomputers in the classroom, science curriculum development, cognitive teacher behavior, applying teacher effectiveness findings to preservice and inservice teacher eduation, inservice teacher education, science process skills, cognitive development and science achievement, secondary analysis results from the 1981-82 National Assessment in Science, spatial learning, problem solving, attitudes toward science, science learning in the elementary school, science for gifted and talented students, and misunderstanding of science concepts. (JN)

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ABSTRACTS OF PRESENTED PAPERS

NATIONAL ASSOCIATION

FOR

RESEARCH IN SCIENCE TEACHING

57TH ANNUAL NARST CONFERENCE

1984

Monteleone Hotel

April 28-30, 1984

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
The Ohio State University
1200 Chambers Road, Room 310
Columbus, Ohio 43212

December 31, 1983

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PREFACE

The ERIC Clearinghouse for Science, Mathematics and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 57th annual conference in New Orleans, Louisiana, April 28-30, 1984.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Ertle Thompson and the NARST Program Committee who obtained the abstracts and organized the program, and to Mrs. Linda Shinn for her assistance in preparing the final copy.

Many of the papers will be published in journals or made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Rodney L. Doran
NARST Research Coordinator

Patricia E. Blosser,
Stanley L. Helgeson,
Editors

This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or U.S. Department of Education.

December 31, 1983

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The gap between the promise of computers in science education and the reality of their use (or disuse) in classrooms looms large. The cognitive consequences of computer learning in science are often mitigated by practical realities such as limited teacher training, poor software, and little hardware. The fulfillment of the promise also requires educational research and policy analysis.

Several projects provide research results and preliminary policy implications from studies of computer learning in science classes. Three different types of cognitively demanding science-related software used under different instructional conditions are reported. Policy implications for instructional design and for use of computers in the classroom are discussed.

Session A-2

A COMPARISON OF COGNITIVE DEVELOPMENT, FIELD INDEPENDENCE/DEPENDENCE COGNITIVE STYLE, AND ACADEMIC SUCCESS OF BACCALAUREATE NURSING STUDENTS

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This study investigated the relationship among cognitive development, field independence/dependence cognitive style, and academic success of baccalaureate nursing students. Although extensive research activities have been directed at the identification of factors associated with the high rate of nursing student attrition, as well as numerous studies which have sought to identify correlates of academic success, none has prescribed an acceptable solution. Prior research has failed to identify individual attributes which are highly correlated to academic performance of nursing students.

The paid volunteer sample consisted of 54 junior level nursing students recruited from one baccalaureate nursing program. Cognitive development was measured by the scores on a videotaped version of the Classroom Test of Formal Operations. The Group Embedded Figures Test was used to evaluate the level of field independence/dependence. The cumulative grade-point average of the three nursing courses which constitute full-time study in the first semester of the nursing program was considered the measure of academic success. Inspection of student performance trends on the various nursing course examinations, in addition to the cumulative Semester I course average, suggested that academic performance of the subjects was very similar to that of the students who did not participate as subjects in this study but who were concurrently enrolled in Semester I.

Data analysis was accomplished by correlating scores on the two research instruments with the measure of academic success, as well as with each other. There was a significant relationship between cognitive development and academic success (r=.39, p=.01). Cognitive development and cognitive style were also found to be significantly related (r=.56, p=.001).

This study provided evidence that a relationship did exist among a student's academic success in the first semester of one baccalaureate nursing program and his/her measure of cognitive development and cognitive style. It was suggested that future research be directed at exploring both constructs longitudinally over the four semesters of the nursing program as well as conducting an investigation of these constructs relative to clinical performance. More information on the relationship between the research variables and attrition obtained through the use of a larger sample size might offer additional diagnostic and prescriptive information to reduce the magnitude of this problem.

Session A-2

ASSESSING THE CONVERGENT AND DISCRIMINANT VALIDITY OF COGNITIVE STRUCTURE REPRESENTATIONS OF SCIENCE CONCEPTS

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Methods were developed to assess the convergent and discriminant validity of cognitive structure representations of students' knowledge. These methods were then applied to the assessment of the convergent and discriminant validity of cognitive structure representations for 17 science concepts pertaining to mechanics. Four different data-gathering tasks (free sort, tree construction, word association, concept structuring) and three different scaling methods (latent partition analysis, hierarchical clustering, multidimensional scaling) were employed in obtaining the representations of cognitive structure. The study's results should serve to encourage the wider use of cognitive structure representations of students' science knowledge in science education research.

Session A-2

MATHEMATICAL RELATIONS BETWEEN SCIENCE REASONING SKILLS AND SOME VARIABLES ASSOCIATED WITH RATE OF INFORMATION ACQUISITION

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Previous research on mathematical modeling of science information acquisition (Anderson, 1983) is extended here to include the assessment of science reasoning skills as a function of the knowledge-acquisition-rate-equation and some of its component factors. Forty-six high school students (I.Q. range 94 - 139) were administered the BSCS "Processes of Science Test" to assess their performance on a science reasoning dimension; this variable is designated R. The students were also given standard tape-recorded listening tasks for 2, 4, and 8 minute duration to determine how well their recall scores agreed with the predicted values N_t generated by the model:

$$N_t = N_o\, e^{\gamma t}\, (S_o e^{-\sigma t} - I_o e^{-\lambda t}),$$

where $N_o e^{\gamma t}$ represents an autogenerative long term memory (LTM) function aiding transfer of information from short term memory (STM) to LTM. The parenthetical factor or modulation factor represents the net stability of STM for holding newly acquired information, t = time lapse since onset of learning.

Using linear regression analysis, R was related to N_t and some component parts of the equation with an error of $p \ll 0.001$. The resulting equation expressing R as a function of N_t is:

$$R = 0.623\, [N_o e^{\gamma t} (e^{-\sigma t} - e^{-\lambda t})]\, {}^{t=8} + 13.3;$$

which is an expanded form of the original equation and provides a mathematical link between science process reasoning ability and information acquisition rate. Hence the model is more comprehensive and includes cognitive skill considered significant to scientific reasoning and inquiry. Additional relations were found between R and the gain factor, and the modulation factor.

REFERENCE

Anderson, O. R. "A Neuromathematical Model of Human Information Processing and its Application to Science Learning." Journal of Research in Science Teaching 20(7): 603-620, 1983.

Session A-2

EVALUATING INSTRUCTION: THE HIDDEN CONCEPTUAL CHANGES

Fred N. Finley
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Evaluation of the conceptual changes resulting from second grade students viewing a science education television program about magnets indicated that a reliable objective testing measure did not reveal important conceptual changes that had occurred. The complementary use of an intensive study of a limited number of students indicated that substantial changes in the percentages of correct conceptions and decreases in the percentages of incorrect conceptions followed the viewing of the program. The most important changes were in the predicates students used to describe and predict magnetic interactions and in an increased use of generic concepts such as non-metals in place of object specific concepts, such as rubber bands. The implications are that intensive studies of small numbers of students complement more typical evaluation procedures and provide insight into the effects of instruction that are not otherwise available.

Session A-3

PAPER SET: THE DEVELOPMENT OF SCIENTIFIC LITERACY IN SECONDARY SCHOOLS

Alexis L. Mitman
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Larry F. Guthrie
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And

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This paper set presents initial results of studies being conducted by the Secondary School Improvement Program at the Far West Laboratory and affiliated Research Fellows at the University of Utah.

The first paper, "Life Science Instruction and Its Relationship to Scientific Literacy at the Intermediate Level," sets the stage by presenting an operational definition of scientific literacy and describing initial results of a comprehensive, multivariate, ethnographic study of science instruction in 12 seventh-grade classrooms.

The second paper, "Task and Teacher Characteristics, Student Interest and Achievement in Seventh Grade Life Science," describes the relationships observed between teacher behavior, instructional format and student interest and satisfaction in the same set of 12 seventh-grade science classes, and draws on ethnographic description of specific classes to give examples of these relationships.

The third paper, "The Opportunity Structure of Scientific Literacy in Six High Schools," describes the results of an ethnographic study focusing on the institutional variables (e.g., tracking structure, teacher assignment, material resources), and curricular variables which facilitate and impede the development of scientifically literate high school students.

The fourth paper, "A Historical and Conceptual Analysis of Tracking in the Science Curriculum," will examine the presence and influence of tracking on the goals, materials and instructional procedures in science education.

Session A-4

SCIENCE TEACHING AS A CAREER CHOICE OF EIGHTH GRADE STUDENTS

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This research evaluated the desirability of science teaching as a career as rated by eighth grade students. An instrument was developed on which respondents placed their own choice of best and worst possible careers as endpoints on a 10 point scale. Forty-five additional careers, including careers in science teaching, science, and teaching of subjects other than science, were then rated by the students with respect to the endpoints.

Careers in teaching were generally rated low by the respondents, with the exception of physical education and mathematics teaching. The respondent's race and educational aspirations were shown to have a significant relationship (0.05 level) with the ratings of some science teaching careers. Additionally, the relationship between the type of job held by the respondent's parents and the rating of science teaching was also significant in some cases.

Session A-4

UNDERGRADUATE SCIENCE MAJORS: FACTORS INFLUENCING CAREER CHOICE

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Approximately 700 freshman students enrolled in introductory biology courses were followed over the four year period of their undergraduate program. Factors that influence initial choices, as well as those that influence successful completion of an undergraduate science major, were examined. Attitudes, aptitudes, and achievement variables that develop during high school as well as college achievement variables were considered. The data were analyzed principally by discriminant analysis.

The variables that discriminated science from non-science groups were achievement variables from the freshman year. Chemistry grade and freshman grade point average were the most discriminating. Physics grades and mathematics grades from courses taken during the sophomore and junior years were less discriminating.

Attitude measures proved to be significant discriminating variables when the sex of the students was considered. Females were more influenced by attitudes, while males appeared to be more achievement oriented.

Session A-4

REASONS POTENTIAL MATH AND SCIENCE TEACHERS CHOOSE NOT TO TEACH; WHAT IT WILL TAKE TO ATTRACT THEM TO TEACHING AGAIN

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In light of the perceived national need for more science and math teachers, this study was conceived to:

1. identify "teaching oriented" students among freshmen at a mid-western engineering school, who have chosen NOT to become teachers;
2. find out what reasons these "potential" science and math teachers give for deciding not to pursue teaching careers;
3. determine what amelioration of these problems would be necessary for them to no longer be factors which would inhibit students from becoming teachers.

Of a random sample of 110 students drawn from the freshman class of 1982-83, 98 participated fully in the study, five chose not to participate, and seven dropped out of school between the time the sample was drawn and contact was made. Each participant took Holland's Self-Directed Search to determine "teaching orientation" as well as locally made instruments to assess their concerns about teaching.

Results showed "teaching oriented" students to have avoided teaching due to low starting salary, lack of job security, low maximum salaries, not wanting to do the work teachers do, poor job availability, discouragement by family and friends, and low prestige of the profession. Starting salaries of $21,693 and of $32,600 for a teacher with a B.A. and 10 years experience were among the changes deemed necessary to make teaching attractive.

REFERENCE

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Session A-4

SENSE OF COMPETENCE IN SCIENCE AS A FACTOR IN THE CAREER DECISIONS OF MEN AND WOMEN

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It was hypothesized in this study that men and women develop a belief about their competence in science during the high school years which is based on their participation in certain science courses, their level of performance in those courses, the effort that they expended, and the informal feedback which they received from peers, parents, and teachers about their science work. This sense of competence, in turn, affects the science decisions which these students make when they enter college. Students who believe they have ability in science are more likely to choose a science curriculum in college and to pursue a science career than are those who don't hold such a belief.

A comparison of men and women in the study showed that women performed very well compared to men through high school biology and chemistry. After that point, however, declines in women's participation and performance in science relative to that of men were observed. Also, women felt they worked harder than men did in high school science courses, but they rated their ability lower, even though actual performance was generally better. The results also showed that, in a path model linking high school and college level variables, this sense of competence in science is a central variable.

It was concluded that women's lower sense of competence in science is an important issue in their reduced participation in science courses and careers.

Session A-5

A NATIONAL STUDY OF FACTORS RELATING TO THE RETENTION OF WOMEN IN SCIENCE

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National studies of teachers who have successfully motivated high school girls to continue in science were conducted. In addition to analyzing instructional techniques, classroom climates, and teacher-student interactions, a selected sample of former as well as all current students were assessed with a variety of attitudinal, cognitive, and socio-cultural measures.

An analysis of their responses by gender strongly indicated that teacher behavior, instructional style, and classroom climate were related to the level of science anxiety, the source of science attribution, and the type of science attitudes held by young women. In addition, when indicators of locus of control orientation, mode of cognitive style, and spatial visualization ability were analyzed by gender, racial origin, and geographical location of school, it was found that differences were related to regional and racial factors rather than to gender.

Analysis of these results indicates directions for change in teaching behaviors and in curricular materials in secondary schools which could raise the science interest levels of young women. It is anticipated that such changes will increase the number of women enrolling in science majors at college and selecting scientific careers.

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Session B-1

THE EFFECTS OF THE SCIENCE METHODS COURSE ON STUDENTS' PERFORMANCE DURING STUDENT TEACHING

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Research in science teacher education has focused mainly on the acquisition of skill and method; little emphasis has been placed on studying the effectiveness of training particularly as it pertains to the field experience. The performance of 38 preservice elementary teachers was examined to identify links between methods course preparation and the application of such skill during the field experience. A qualitative research design was used which made use of observation and interview. Considerable variability occurred in the application of training. The factors influencing that application were preparation in science, compatibility with the supervising teacher, the social structure of the school, and the pre-entry attitudes of students.

Session B-1

SCIENCE TEACHERS' BELIEFS ABOUT THE NATURE OF SCIENCE AND THE SELECTION, IMPLEMENTATION, AND DEVELOPMENT OF INSTRUCTIONAL TASKS

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Progress and advances in and among various fields of science, science education, and technology have, over the past two decades, had the effect of raising society's level of understanding about the scientific enterprise. The focus of the study was an examination of two critical aspects of the scientific enterprise: science teachers and scientific theories.

Over the last two and one-half decades, historians and philosophers of science have focused on the analysis of the structure of scientific theories. The research question, then, is whether or not teachers should make the content and structure of scientific theories a part of their decision-making process in the selection, development, and implementation of instructional tasks.

The purpose of the study was to assess the degree to which teachers made decisions based on scientific theories. Two principal research questions are:

1. What considerations, if any, do science teachers give to the nature of and role of scientific theories in their selection, development, and implementation of instructional tasks?

2. What benefits might occur in instructional tasks if teachers were to include in their decision-making considerations for the nature of scientific theories?

The research employed methodological procedures borrowed from ethnography. Spradley's "Development Research Sequence" and the validation process of triangulation were followed. The research site was a comprehensive four year high school.

Two findings result from the first research question - 1) science teachers give little consideration to scientific theories in their instructional task decision-making, and 2) instructional tasks decisions are dominated by: a) teaching propositional knowledge; b) using select scientific processes as vehicles for teaching propositional knowledge; c) teaching objectives outlined in curriculum guides; and d) coping with pressures of accountability.

The finding from the second research question is that the philosophy of science can provide a mechanism for restructuring secondary level science curricula because evaluating and interpreting scientific knowledge will necessarily involve learners in an examination of what is known by science, what is not presently known by science, and what may be known by science.

Section B-1

A COST-EFFECTIVENESS ANALYSIS OF INTERVENTIONS FOR IMPROVING SCIENCE EDUCATION

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The purpose of this research was to conduct an analysis of the cost-effectiveness of the many interventions proposed for improving science education. Interventions were grouped by objectives sought and analyzed in terms of per pupil annual cost and effectiveness as determined by extant empirical research. For interventions associated with each objective, and for facilitating interventions, matrices display the single interventions in terms of their cost and effectiveness. These analyses highlight the systemic nature of the situation. Single interventions have relatively small potential for substantial impact. There are clusters of interventions with potential for producing substantial improvement in science education. The desired goals must be identified and there must be a willingness to pay a significant but reasonable price.

REASONS GIVEN BY STUDENTS FOR AND AGAINST THE FURTHER STUDY OF SCIENCE FOLLOWING COMPLETION OF A TWO-YEAR HIGH SCHOOL SCIENCE REQUIREMENT AS A BASIS FOR COURSE/ CURRICULUM CHANGE

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The study has two main purposes: (1) to identify the most important reasons for and against taking science beyond a two-year science requirement; (2) to identify areas of possible change that might increase science enrollment.

The sample of this study was comprised of 306 students who were enrolled (Spring, 1982) in three high schools located in a relatively affluent community in suburban Chicago.

The study revealed that the following reasons for taking science were checked by the highest percentages of science takers:

1. admission to college (85.16%);
2. majoring in a science-related field in college (59.35%);
3. understanding how things work (60.00%);
4. having the aptitude (50.97%).

It also revealed that the following reasons for not taking science were checked by the highest percentages of non-science takers:

1. interest in other subjects (88.08%);
2. lack of interest in science (74.17%);
3. not important for career (68.21%);
4. don't have the aptitude (42.38%).

In addition, the following changes were checked by the highest percentages of all the subjects:

1. if science applications to daily life were emphasized (57.52%);
2. if grades became less dependent on exams (56.88%);
3. more individualization (44.77%);
4. if abstract concepts became understandable (45.42%).

Session B-2

RELATIONSHIP AMONG SELECTED VARIABLES AND THE NUMBER OF SCIENCE COURSES COMPLETED BY BLACK HIGH SCHOOL SENIORS

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The problem in this study was to identify a set of variables which characterize black secondary science students. The population consisted of a subsample of 3,963 black high school seniors from "The High School and Beyond 1980 Base-Year Survey." Multiple linear regression procedures were used to determine the F-tests. The alpha level was .05.

A significant relationship between socioeconomic variables and science class selection by black high school seniors was indicated. Also, significant relationships were found for locus of control, mother's level of education, mother's expectation, math standardized scores, English grades, and self-concept. The effect of mother having worked accounted for no significance. The effect of self-concept and the effect of locus of control were not related significantly to science class enrollment over and above socioeconomics variables.

REFERENCE

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Session B-2

STUDENTS' SCIENCE RELATED ATTITUDES, SELF EVALUATION OF ABILITIES TO DO SCIENCE, AND PERCEPTION OF PAST EXPERIENCE FOLLOWING A TWO YEAR HIGH SCHOOL SCIENCE REQUIREMENT

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Using multivariate statistical techniques, an investigation was carried out on how high school students who completed two year science requirements compare in their science related attitudes (seven dimensions), self-evaluation of abilities to do science, and perception of past experience with science courses. Two instruments, Test of Science Related Attitudes (TOSRA) and a questionnaire, were administered to 300 students who were enrolled (Spring 1982) in three high schools located in a relatively affluent community in suburban Chicago.

The study revealed an overall highly significant difference between sexes and between students who continue in science and those who do not continue on all the nine dependent variables taken together. In addition, the discriminant analysis revealed that the differences between males and females depend largely on leisure interest in science, self-evaluation of abilities to do science, and perception of past experience. It also revealed that the differences between science and non-science takers depend mostly on enjoyment of science, self evaluation of abilities to do science, and perception of past experience.

TOSRA scales were found to be highly reliable. The discriminant validity of these scales, however, was found to be quite low.

Session B-3

TEACHER RESPONSIBILITY FOR STUDENT SUCCESS AND FAILURE AND OBSERVED TEACHING CHARACTERISTICS AMONG SECONDARY SCIENCE AND MATHEMATICS TEACHERS

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The study compared selected teacher beliefs and verbal behaviors among secondary science and mathematics teachers. Teacher beliefs included teacher responsibility for student success and failure. These beliefs were measured by the Responsibility for Student Achievement (RSA) Questionnaire which has the locus of control construct as a theoretical basis. Teacher verbal behavior included (1) indirect and (2) direct behaviors and (3) praise and (4) criticism. These behaviors were measured with the Reciprocal Category System (RCS) which is consistent with the methodology of interaction analysis. Comparisons were made on the basis of the following teacher classifications: (1) science/mathematics, (2) junior high/senior high, and (3) teachers of advanced classes/teachers of basic classes.

Only the advanced class/basic class comparisons produced significant differences in either teacher use of praise or criticism. Advanced and basic class comparisons produced significant differences in both teacher beliefs and behaviors. Teachers of basic students assumed more responsibility for student success, assumed less responsibility for student failure, and were more direct in verbal behavior than teachers of advanced students. In comparisons of teacher gender, female teachers were significantly higher in incidences of indirect behavior and combined indirect-direct behavior.

Session B-3

TEACHER INSTRUCTION AND STUDENT PERFORMANCE IN BALANCING CHEMICAL EQUATIONS

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The instruction, by four high school teachers, on introductory chemical equation balancing was examined. The content-specific knowledge of the instruction was compared with the knowledge that 42 of their students possessed after the instruction. Students were given a brief examination of their ability to balance chemical equations and were interviewed to determine what relevant knowledge they held. Comparisons were made at three knowledge levels (syntactical, empirical, and theoretical) on selected concepts and propositions necessary for balancing simple chemical equations.

The results indicate that the instruction of the four teachers was heavily weighted towards the syntactic knowledge level. More significantly, these teachers did not stress the relationships between the manipulation of chemical symbols and the empirical and theoretical components of the chemistry from which the equations were derived. All of the students learned to balance the simple chemical equations of the composition-decomposition type and attained the concepts and propositions at the syntactic level of knowledge. However, the majority of the interviewed students failed to develop a consistent or complete understanding of the knowledge at any one level except the syntactic.

Suggestions are made for improving the instruction to facilitate the students' chemical understanding of the equation balancing process.

Session B-3

TEACHER BEHAVIOR AND STUDENT COGNITIVE LEARNING IN FIFTEEN BSCS GREEN VERSION BIOLOGY CLASSES

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The purpose of this study was to seek associations between the behaviors of teachers in regular BSCS classrooms and the cognitive learning of their students.

Eight BSCS biology teachers from two public high schools and 353 of their 10th grade male and female students constituted the study population. Seven of the teachers taught two classes in the study; the remaining teacher taught one class. Both high schools were in a large suburban school district.

Perceptions of teacher behavior were collected from students' checklists. A biology test was completed by students as a pre- and post- content measure.

FINDINGS

1. Classes taught by teachers who ranked higher on a direct-to-indirect scale of verbal behaviors showed a higher mean content gain than the classes of teachers who ranked lower on this scale.

2. Classes taught by teachers who ranked higher on a less-to-more inquiry scale showed a higher mean content gain than the classes of teachers who ranked lower on this scale.

3. Teachers who tended to be more indirect in verbal behaviors also tended to be more inquiry-oriented in their procedural behaviors.

4. Specific teacher verbal behaviors that yielded positive association with students' content gain showed that strategies that encouraged student participation were highest.

5. Analysis of specific teacher procedural behaviors showed those higher in association with student content gain were those indicating structured teaching strategies such as pre-planning.

Session B-4

THE EFFECTS OF USING CONCRETE ANALOGIES ON FORMAL AND NONFORMAL OPERATIONAL NURSING STUDENTS' UNDERSTANDING PHYSIOLOGICAL AND PATHOPHYSIOLOGICAL ABSTRACTIONS

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The purpose of this study was to examine the effectiveness of the use of concrete analogies on learning of selected physiological and pathophysiological abstractions in nursing by nonformal and formal operational students. A sample of 65 nursing students was utilized as subjects. The students' cognitive level was determined by the use of the videotape version of a "Classroom Test of Formal Operations." The subjects were classified as either formal operational or nonformal operational and were randomly assigned to either the control group or the experimental group. Both the experimental and control groups had two subgroups: formal and nonformal operational subjects.

A pretest-posttest design was utilized. After a pretest, the subjects had classes on renal processes; hyperosmolar imbalances: nursing implications; hypoosomolar imbalances: nursing implications; and pressure/flow relationships: nursing implications. The experimental group had concrete analogies which utilized perceptible objects and/or relationships representing or resembling abstractions. The control group had classes without the use of concrete analogies.

The data indicated that out of 65 subjects, ranging in age from 21 to 48, that 27 (41.5%) were formal operational and 38 (58.5%) were nonformal operational. Analysis of covariance was utilized and indicated that, for the overall gain scores, the experimental group did significantly better than did the control group (0.000 level of significance). There was no significant difference between the experimental group and control group for the formal learners, except on one subtest (0.026 level of significance). The data suggest rather strongly that the experimental group did significantly better than did the control group for nonformal learners (0.000 level of significance).

Session B-4

EFFECTS OF TRADITIONAL AND DISCOVERY INSTRUCTIONAL APPROACHES ON LEARNING OUTCOMES FOR LEARNERS OF DIFFERENT INTELLECTUAL DEVELOPMENT: A STUDY OF CHEMISTRY STUDENTS IN ZAMBIA

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The purpose of this study was to examine the differential effectiveness of traditional and discovery methods of instruction for the teaching of science concepts, understandings about science, and scientific attitudes to learners at the concrete and formal level of cognitive development.

The dependent variables were achievement, understanding science, and scientific attitude. These were assessed through the use of the ACS Achievement Test (high school chemistry, Form 1979), the Test on Understanding Science (Form W), and the Test on Scientific Attitude, respectively.

Mode of instruction and cognitive development were the independent variables of the study.

The subjects were 120 Form IV (11th grade) male students enrolled in chemistry classes in two boys' schools in Lusaka, Zambia. Sixty of these were concrete reasoners (mean age = 18.23) randomly selected from one of the two schools, and the remaining 60 subjects were formal reasoners (mean age = 18.06) randomly selected from the second boys' schools.

Each of these two groups was randomly split into two subgroups with 30 subjects in each. The traditional and discovery approaches were randomly assigned to the two subgroups of concrete reasoners and to the two subgroups of formal reasoners.

Prior to instruction, all the subjects were pretested using the ACS Achievement Test, the Test on Understanding Science, and the Test on Scientific Attitude.

The subjects received instruction covering eight chemistry topics over a period of approximately 10 weeks, after which they were posttested using the same standard tests.

The scores earned by the subjects on the three tests were subjected to the two-way analysis of covariance, with pretest scores serving as covariates. The level of significance adopted in all the analyses was .05. The Tukey WSD technique was used as a follow-up test where applicable.

It was found that (1) for the formal reasoners, the discovery group earned significantly higher understanding science scores than did the traditional group. For the concrete reasoners, mode of instruction did not make a difference; (2) overall, formal reasoners earned significantly higher achievement scores than did concrete reasoners; (3) in general, subjects taught by the discovery approach earned significantly higher scientific attitude scores than did those taught by the traditional approach. However, in the area of achievement, the traditional group outperformed the discovery group.

From these findings, it was concluded that the traditional approach might be an efficient instructional mode for the teaching of scientific facts and principles to high school students, while the discovery approach seemed to be more suitable for teaching scientific attitudes.

The discovery approach also tended to be more effective than the traditional approach in promoting understanding about science and scientists among formal operational learners.

Session B-4

THE RELATIONSHIP BETWEEN PIAGETIAN COGNITIVE DEVELOPMENTAL LEVELS AS MEASURED BY THE BURNEY LOGICAL REASONING TEST AND SELECTED SCHOLASTIC VARIABLES OF PROSPECTIVE KOREAN SECONDARY SCHOOL TEACHERS

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The purposes of this study were: (1) to examine the relationship between Piagetian cognitive levels of prospective Korean secondary school teachers and their scholastic achievements or their indexed data, and (2) to derive an effective prediction equation for their cognitive levels.

The data were collected using 200 freshmen (100 males and 100 females) enrolled in the College of Natural Sciences, Chungnam National University, Korea, during Fall Semester, 1981. The subjects were administered the Burney Logical Reasoning Test to determine their cognitive levels. The Sequential Test of Educational Progress was used to measure the science achievement of the prospective teachers. The Group Embedded Figures Test was used to measure the field-independent/field-dependent cognitive style of the subjects. The statistical treatments used in the study were: (1) Pearson product-moment correlation coefficient; (2) multiple regression procedure; (3) stepwise method; and (4) Tukey jackknife for cross-validation. The contour plot method was introduced in demonstrating small changes of the criterion variable in prediction studies.

An analysis of the findings in this study suggests the following conclusions: (1) only 40% of the total sample was found to work at the formal operational level; (2) science achievement, cognitive style, and intelligence quotient were correlated very significantly ($\underline{p} < .01$) with Piagetian cognitive levels; (3) the contour plot method would provide good information about small changes of the criterion variable even though most statistical treatments neglect to address these small changes; (4) the total set of predictor variables succeeded in predicting the Piagetian cognitive levels; (5) different subsets of predictor variables were chosen for each sample through the stepwise method; and (6) predictive validities of stepwise prediction equations developed for the total, the male, and the female samples were found to be 0.250, 0.235, and 0.236, respectively.

In general, the findings of this study demonstrated the importance of science achievement and cognitive style of prospective teachers for their cognitive development. Finally, further studies using the contour plot method are recommended for the prediction of Piagetian cognitive levels.

Session B-5

DELINEATING CLASSROOM VARIABLES RELATED TO STUDENTS' CONCEPTIONS OF THE NATURE OF SCIENCE

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An adequate understanding of the nature of scientific knowledge is a well recognized attribute of the scientifically literate individual. However, little is known about how the science teacher can promote adequate conceptions of science.

The data did not support the traditional assumption that a teacher's conception of science is significantly related to changes in students' conceptions. Rather, it appears that, beyond some essential level of knowledge, a teacher's viewpoint is not significantly related to changes in students' conceptions. Identifying those classroom variables related to students' conceptual changes provided the focus for additional analysis.

Particular interest was directed toward students' overall conceptions of scientific knowledge and their conceptions of its tentative nature. Twenty-five classroom variables were found to be significant for both overall and tentative conceptions while twelve were found to be scale-specific. In general, "successful" classrooms were typified by frequent inquiry-oriented questioning with little emphasis on rote memory. Implicit references to the nature of science were commonly found. Furthermore, successful teachers were pleasant, supportive, and frequently used anecdotes to promote instruction and establish rapport. Classrooms exhibiting large changes in overall conceptions, but not with respect to notions of the tentative nature of science, were characterized by emphasis on the depth, breadth, and accuracy of content.

Session B-5

SOME MODEST CLAIMS FOR THE VIRTUE OF SCIENCE AS A CONTEXT WITHIN WHICH THE DEVELOPMENT OF ADOLESCENTS MAY BE CHANGED: AN EXPLORATORY STUDY

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It is argued that if the cognitive development of adolescents is to be permanently affected by training procedures offered within the context of science courses, a radical change will be required in the training and professional expertise of the high school science teacher. The previous literature on intervention studies is briefly reviewed, and a list of general principles is drawn up in an eclectic way. Within the context of a general argument for the abandonment of any simple "cause-and-effect" model of intervention, an outline of a plan for unobtrusive intervention over a period of two years is sketched within the context of a general science course for early adolescents. As an earnest of the procedure recommended, some of the effects, non-effects, and problems encountered in a two and one-half month pilot study on British 14 year-olds are presented. The training content was five of the Piagetian formal operational schemata, but these were presented within the context of a normal physical course.

Session B-5.

A SURVEY OF ACCIDENTS IN THE SECONDARY SCHOOL SCIENCE LABORATORY

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A survey of 102 secondary school science teachers, department chairpersons, and supervisors concerning their laboratory accident-rate was conducted during the 1980-1981 school year. The results indicate that accidents occur on a weekly basis, even among a sample of experienced teachers interested in safety. Four-thousand, seven-hundred and twenty-one accidents were reported, which is equivalent to 1.29 per teacher per week. Thirty-seven per cent of the respondents reported a major accident had occurred in their teaching experience (one requiring a doctor's care).

Other findings of importance were that laboratory facilities appear to be less than comprehensive in the area of eye safety, and that those teachers with advanced degrees and the most experience have significantly fewer accidents.

Session C-1

A RESEARCH AND DEVELOPMENT AGENDA FOR COMPUTING IN SCIENCE EDUCATION

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The purpose of this symposium is to set forth research and development ideas related to instructional computing in science. Instructional computing has an important role to play in both teaching and learning science. Some studies have been done relating to appropriate ways to use computing in science instruction but much more work is needed to provide direction for computer-related decisions made by policy makers, instructional developers, curriculum planners and teachers.

The symposium will focus on computing in three areas of science teaching--using computers to aid laboratory learning, promoting abstract thinking skills, and acquiring teaching skills needed to use computers in classrooms. In each area, previous work will be reviewed and proposals will be made for needed research and development.

Following presentation of the three papers, a critique of the proposals will be made by a person knowledgeable in the research areas and in applications of computing to science instruction.

Session C-1

RESEARCH USING MICROCOMPUTERS IN GATHERING, DISPLAYING AND ANALYZING LABORATORY DATA

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More and more schools are using microcomputers to connect to laboratory equipment and are using microcomputers as laboratory instruments. Research on how students learn to use microcomputers to gather, analyze and display data is becoming an interesting avenue for scholarly research. A research agenda in this area might look similar to the following:

1. Research on the characteristics of the learners as they use microcomputers in laboratory settings.

    1.1 Data gathering
    1.2 Analyzing data
    1.3 Displaying data

2. Research on the understanding of computers.

    2.1 Connecting instruments (analog to digital conversion)
    2.2 Calibration of instruments
    2.3 Probability distribution of research data

3. Research on the development of processes.

    3.1 Modifying computer programs to keep results in the proper range of data
    3.2 Modifying instruments to allow for better gathering of data
    3.3 Selecting and modifying "best fits" to the data

The use of the microcomputer has made the gathering and interpretation of data much easier in the science laboratory. Using the above agenda, such questions could be asked as:

> Do students understand science better who utilize the computer to graph data and develop lines of best fit than do those who must graph the results themselves?
>
> Do students choose to modify the lab instruments to fit the computer program or modify the program to fit the computer, and under what condition do they recognize the advantages of either?

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Developing such an agenda will enable researchers in NARST and other organizations to coordinate efforts and determine answers to both theoretical and practical research questions.

Session C-1

COMPUTER RELATED RESEARCH AND DEVELOPMENT IN TEACHER EDUCATION

James R. Okey
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The potential for both increasing learning effectiveness and providing up-to-date preparation for further education and employment make it imperative that science teachers integrate computing into instruction. If that view is accepted, a host of questions arise about how to effectively and efficiently move away from a condition of few computers in classrooms, little integration into instruction, and low levels of skill by science teachers.

This paper will focus on research and development activities in three areas associated with science teacher education in computing. First will be examined the acquisition of computing skills by teachers. What skills are important and how can they effectively and economically be acquired? The magnitude of the task of retraining teachers to use computers is so massive that alternatives to present practices must be considered. The second area taken up will be that of classroom computing practices and decisions. How often does the teacher use computers, with what students, with what content, and in what kind of setting? Present teaching practices fully occupy the teaching time. Introducing computers means that some things presently done must go. The third area to be considered is a controversial one -- can effective teaching of science be accomplished with no teacher present? So many science teachers are out of field and so many districts fail to offer science courses because they lack trained teachers that alternatives to locally staffed science courses need to be considered. The availability of computers and telecommunication capability offer alternatives to poor quality locally-taught science courses.

Session C-1

INTERACTIVE COMPUTER GRAPHICS AND THE TRANSITION FROM CONCRETE MANIPULATION OF OBJECTS TO ABSTRACT THINKING

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Educators have generally accepted a learning model which suggests that a concept is acquired first through manipulation of concrete objects followed by transformation of the concrete objects into semi-concrete representations and followed by internalization of the concept through abstract representations (i.e., symbols, letters, numbers).

The increasing demand for computer use in the classroom needs to be examined in terms of its unique role in the learning process (concept and development) and individual cognitive style (i.e., brain hemisphericity). Microcomputer use is suggested as a link between the concrete and abstract levels of thinking in concept development. Graphics simulations provide interactive semi-concrete representations. Concept development has recently been related to brain hemisphericity development and the shift from right-hemisphere to left-hemisphere processing strategies. Right hemisphericity has been documented for culturally diverse groups (i.e., non-white ethnic groups). The microcomputer can focus upon the strengths of culturally and intellectually diverse individuals. The child's preferred mode of processing can be recognized, utilized, and integrated into improved instructional strategies for the development of science and mathematic concepts.

Session C-2

TWELVE-YEAR LONGITUDINAL CASE STUDIES OF SCIENCE CONCEPT LEARNING

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Grade one and two students were given audio-tutorial (A-T) science lessons during 1971-73. These 191 students were interviewed periodically for twelve years, along with a group of 48 students who were not A-T instructed. Clinical interviews were analyzed using a "concept mapping" technique, and these concept maps show changes in conceptual frameworks for children over the twelve-year span. Data indicate that young children can acquire basic science concepts in primary grades and that the influence of this early learning persists throughout the school years, including later years when formal science courses are taken. Concept mapping shows promise as a research tool for cognitive learning studies.

Session C-2

FORGETTING VERSUS SAVINGS: THE MANY FACETS OF LONG-TERM RETENTION

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Retention has various facets, each with its special educational implications. This paper reports on a longitudinal study attempting to gain better insight into the facets of retention, which it is hoped will lead to relevant educational inferences. Our study focused on retention of chemistry-related materials over a three year interval from junior to senior high school in Israel. Matched data were analyzed in order to avoid selection effects due to sample attrition during the follow-up. The investigation included two groups of students, only one of which studied a chemistry-centered course in junior high school (grade 8). Despite the fact that chemistry is taught again only at grade 10, significant long-term retention of the grade 8 learning exists. Our conclusion is based on the following findings: (1) at the beginning of grade 10, students who previously studied chemistry in grade 8 had significantly higher recall and recognition scores; (2) their feeling of familiarity, exhibited by a self-report on retention, was higher; (3) a relearning task showed significant "savings." Students' feelings of familiarity with previously studied materials were found to be higher than were their actual recall and recognition scores. Achievement in the relearning task suggests that the high familiarity is - at least partly - a reflection of real savings within students' cognitive structures. Namely, the functional availability of previous learning is greater than the readily retrieved knowledge. All the relevant retention information - recall, recognition, savings, as well as feeling of familiarity - should be taken into consideration by both teachers and curriculum developers.

Session C-2

THE EFFECT OF PRESCRIBED INSTRUCTION ON THE MASTERY OF SCIENCE CONCEPTS BY NONFORMAL STUDENTS

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Piagetian psychology suggests that formal (abstract) concepts can only be comprehended by individuals who possess formal operations. This study examined the effectiveness of an activities approach to instruction on the mastery of biological concepts, and whether this strategy would aid nonformal operational students master formal concepts. The sample of 200 high school biology students -- 100 forming a treatment group and 100 forming the control group -- was stratified by cognitive ability level and by the time of day that they received instruction. The findings were that the experimental treatment was ineffective at enhancing science mastery, and that nonformal operational students were not aided in the learning of formal concepts.

Session C-3--D-3

RESEARCH METHODS SEMINAR/WORKSHOP: ANALYZING SCIENCE TEXTBOOK PROSE: A WORKSHOP IN PRACTICAL METHODS FROM COMPREHENSIVE RESEARCH

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A number of recent papers and presentations within the science education community evidence a disparity between interest in and actual use of methods of text analysis in research, instruction, and text evaluation. The primary purpose of the workshop is to train participants in the application of three practical methods of text analysis currently used in comprehension research. These methods are empirical pausal or linguistic unit analysis, propositional analysis, and relational mapping.

The rationale for each method will be described, followed by instruction in its use. Participants will practice the methods individually using actual science textbook passages and discuss their efforts in small groups. The groups' consensus analyses will be recorded on overhead transparencies to permit discussion and evaluation by all participants. Advantages and difficulties in using each method will be assessed. Potential uses for the methods in research, instruction, and evaluation will be described and critiqued by the presenter and participants. Participants will receive a workshop packet which will include sample passages, analyses, and references to assist them in continued study and practice of the methods.

Session C-5

PATTERNS OF HIERARCHY IN FORMAL AND PRINCIPLED MORAL REASONING

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Measurements of formal reasoning and principled moral reasoning ability were obtained from a sample of 99 tenth grade biology students. Specific modes of formal reasoning (proportional reasoning, controlling variables, probabilistic, correlational, and combinatorial reasoning) were first examined. Findings support the notion of hierarchical relationships which exist among those variables. Further results from factor analysis provide evidence that the variables represent specific cognitive structures that are interdependent with each other and precede operations in development. Finally, significant relationships were found to exist between the different modes of formal reasoning and principled moral reasoning. Combinatorial and correlational reasoning were found to significantly account for 22 percent of the variance in principled moral reasoning. Theoretical and educational implications were discussed.

Session C-5

PROBLEMS IN ADMINISTERING PIAGETIAN TASKS TO ADULT SAMPLES

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Piagetian tasks have primarily been administered to school age samples in attempts to replicate the findings of Jean Piaget. When these tasks are administered to adult samples, certain problems become apparent that are masked or hidden in the results from younger subjects. In a study conducted on a sample of medical students and physicians, several problems taken to be generic to adult populations became apparent. These included: affective response interference, differentiation between cognitive development and situational learning, tendency by subjects to obfuscate responses when unsure of the problem, distortions due to lockstep task procedures, and problems of scoring protocols. The significance of the findings of this study indicate that rather than standardization of procedure, standardization of conceptual understanding provides the reliability necessary for important use of the clinical interview method.

Session C-5

STUDENT OPINIONS OF THE LABORATORY ACTIVITIES IN THE LEARNING CYCLE IN SECONDARY SCHOOL PHYSICS

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The research to be reported was carried out over a period of three semesters in three physics classes. The students had elected to enroll in secondary school physics and experienced a complete course built upon the learning cycle (exploration, conceptual invention, and expansion of the conceptual invention). The students experienced 29 learning cycles in one complete academic year. Seven times during the research the students were given data through readings, teacher demonstration, video-taped demonstrations and lectures. The students also experienced the same four techniques during the learning cycle's expansion phase instead of using the laboratory. During those seven periods four students from each of three classes were each interviewed four times. The data reported here were generated and recorded during those interviews.

Actual student dialogues will be reported. The principal finding was that students believe they learn more physics and learn it more thoroughly if they have extensive laboratory experience. As one student stated: "I think people pay more attention to the lab if we really do it. Sometimes it's a pain but it's much better."

Session D-1

ANALYZING HIERARCHICAL RELATIONSHIPS AMONG MODES OF COGNITIVE REASONING AND INTEGRATED PROCESS SKILLS: A PAPER SET

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Much curriculum development and instruction related to process skills is carried out in science classrooms with little regard to the prerequisite skills necessary for the acquisition of the integrated process skills. Some effort has been put into developing logical hierarchies (e.g., S-APA), but no efforts have been published that would signify a concentrated effort to empirically establish the super- and sub-ordinate relationships of these skills. This paper set is designed both to communicate work that is being carried out in the Science Education Research Lab at the University of Georgia and to stimulate interest in the area of research which needs immediate attention from science education researchers.

The proposed presentation consists of three different, but closely related, papers to be presented by personnel working on the project. The first paper addresses the potential importance of the prerequisite relationship between modes of reasoning, as defined by Piaget, and the science process skills. A review of pertinent literature is included. The second paper begins with a historical review of hierarchical analysis and then focuses on the ordering theoretic procedure and latent structure probabilistic method, both recently developed. The last paper focuses on the tentative super- and sub-ordinate relationships between process skill and Piagetian reasoning modes that were discovered using the hierarchical analysis techniques described above.

Session D-1

THE POTENTIAL AND IMPORTANCE OF A PREREQUISITE RELATIONSHIP BETWEEN REASONING MODES AND INTEGRATED PROCESS SKILLS

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This proposed paper uses both a logical and empirical approach to address the question of the potential prerequisite relationship between various reasoning modes (i.e., conservational, propositional, correlational, proportional, and combinatorial reasoning, and control of variables) and the mastery of the integrated science process skills. This question has remained latent through two decades of curriculum development and has been largely ignored in recent efforts to define and improve middle and secondary school science programs.

A review of existing research will be presented which in a meta-analytical sense shows the mean correlation between the two sets of skills to be $r = .70$. This covarying relationship which is supported in all the research reviewed (e.g., Padilla, Okey, & Dillashaw, 1983; Tobin & Capie, 1982; Walkosz & Yeany, 1983) suggests an intricate cognitive tangle of the cognitive and scientific process skills. Additional research (e.g., Bredderman, 1973; Lawson, Blake, & Nordland, 1975) reviewed indicates that formal reasoning abilities are essentially developmental (i.e., not directly teachable), while the integrated process skills can be acquired through identifiable learning processes (e.g., Tobin & Capie, 1982; Padilla, Okey, & Garrard, in press; McKenzie, 1983). If one generally accepts the developmental versus teachable dichotomy of the two sets of skills, then in view of the persistent covariance of the two, one must consider the existence of a hierarchical relationship among the formal reasoning skills and the integrated process skills.

The existence of such a relationship would have a profound influence on our attempts to design and implement effective curriculum and teaching strategies, especially for middle and high school science classes. The purpose of this paper is to look at the present evidence and point up the need for a thorough investigation into the hierarchical nature of the skills addressed in many middle and secondary science programs.

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Session D-1

METHODOLOGICAL ADVANCEMENTS RELATED TO IDENTIFYING HIERARCHICAL RELATIONSHIPS AMONG SCIENCE CONCEPTS OR SKILLS

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The investigation and discovery of hierarchical relationships among concepts and skills addressed by school curricula has been hampered by a lack of analytical techniques to generate or test hypothesized relationships. Recent advances have been made in techniques to measure latent structure and non-linear (branching) relationships among skills and concepts.

Gagne and his colleagues (e.g., Gagne & Paradise, 1961) were pioneers in hierarchical model validation, using logical task analysis procedures which focused on prerequisite skills and vertical transfer.

Later researchers used scalogram analysis to study prerequisite relationships (e.g., Kofsky, 1966; Allen, 1970). These procedures were criticized because of no estimate of chance errors, lack of an index of validity, inconsistency, and a tendency for high and misleading values. In addition, scalogram analysis is limited to linear or vertical transfer and cannot serve to identify branching relationships.

The ordering theoretic procedure has been adopted in recent studies to identify both linear and non-linear relationships among tasks. Airasian, Madaus and Woods (1975) compared the ordering theoretic method with scalogram analysis. They concluded that the ordering theoretic method identified a branched, non-linear hierarchy which had higher reproducibility and scalability than the linear hierarchy identified by the scalogram analysis method. But, since ordering theoretic procedures depend on an arbitrary choice of tolerance levels, the procedure is not totally adequate, either.

The most recent analysis procedure is the latent structure probabilistic method. This approach evaluates the degree to which a logically or empirically generated hierarchy (possibly generated by ordering theoretic procedure) provides a reasonable model for the data. The latent structure procedure incorporates inferential statistical criteria and involves less arbitrary methods for acceptance or rejection of a given hierarchy. It also provides for a statistical comparison among alternate hierarchies fitted to the same data.

The purpose of this paper is to summarize the state of the art in relation to hierarchical data analysis and describe the latest procedures for identifying relationships among skills and concepts being taught in science classes.

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Session D-1

SUPER- AND SUB-ORDINATE RELATIONSHIPS AMONG THE INTEGRATED PROCESS SKILLS AND PIAGETIAN MODES OF REASONING

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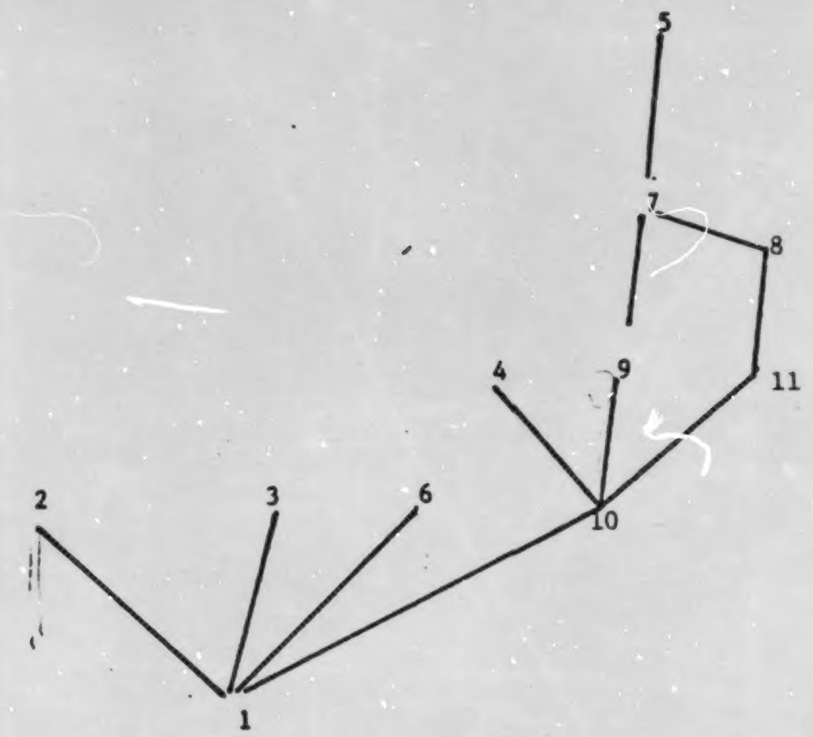
The purpose of this paper is to present the results of data analysis used to identify both linear and non-linear relationships among integrated science process skills and the various modes of logical reasoning ability. The methods used to generate the hierarchical models included both ordering theoretic procedures and latent structure probabilistic methods.

The data sources were 628 students from grade six through college level. Data were collected by using the Group Assessment of Logical Thinking (GALT) (Roadranga, Yeany & Padilla, 1983) and the Test of Integrated Process Skills (TIPS) (Burns, Wise & Okey, 1983). Since hierarchies are best revealed in situations where subjects are responding correctly to lower level skills while incorrectly responding to higher level skills, most of the analysis centers on the transitional students in this sample.

The results indicate that non-linear (branching) hierarchies are involved in learning the integrated process skills in relation to various modes of logical reasoning ability. Even though this type of analysis needs to be expanded to more subjects and measures, the present hierarchical structure appears to be as follows:



where:

1 = conservation reasoning

2 = proportional reasoning

3 = control of variables

4 = probabilistic reasoning

5 = correlational reasoning

6 = combinatorial reasoning

7 = identifying variables skill

8 = hypothesizing skill

9 = operationally defining skill

10 = designing experiments skill

11 = graphing and data interpreting skill

Although these results must be viewed as tentative, the existence of some hierarchical relationship among the integrated process skills and formal reasoning abilities is apparent. The significance of this needs to be realized in science teaching and curriculum development. Certain skills may need to be acquired before teaching can be effective at the next level.

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Session D-2

THE RELATIONSHIP BETWEEN COGNITIVE DEVELOPMENT OF HIGH SCHOOL STUDENTS AND THEIR ACHIEVEMENT IN CHEMISTRY

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The primary purpose of this study was to determine if there is a significant difference between the achievement of high school chemistry students classified as formal operational and that of those classified as non-formal operational. Complete data were obtained from 171 students who were enrolled in first year high school chemistry. Cognitive development was assessed by the Lawson test. Scores on the ACS Exam were used as a measure of achievement in high school chemistry. Students who scored 13-15 on the Lawson test were classified as formal operational, students who scored 5-10 were classified as non-formal operational, and students who scored 11 or 12 were not used in the analysis. The mean score for the formal operational group on the ACS Exam was 59.5 and the mean score for the non-formal operational group was 42.0. The results indicate that the formal operational group scored significantly higher on the ACS Exam than did the non-formal operational group ($t_{123} = 4.66$, $p > 0.01$).

The secondary purpose of this study was to divide the items on the ACS Exam into two categories: those that discriminated formal operational students from non-formal operational students and those that did not. Fourteen items were found to discriminate ($p > 0.001$). Items were then examined to discover how the discriminating items differed from the non-discriminating items in terms of cognitive demand. This analysis indicated that 11 of 14 (or 78%) of the discriminating items required the use of proportional reasoning whereas only 10 of 66 (or 15%) of the non-discriminating items required the use of proportional reasoning. Proportional reasoning appears to be the ability which differentiates the performance of formal operational from non-formal operational students on the ACS Exam.

Session D-2

A STUDY OF THE EFFECTS OF COOPERATIVE BIOLOGICAL RESEARCH EXPERIENCES ON HIGH SCHOOL BIOLOGY STUDENTS, TEACHERS, AND UNIVERSITY SCIENTISTS

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This study examined the effects of cooperative biological research experiences involving high school biology students, their teachers, and scientists on (1) the attitudes of the students and teachers toward science and the research experience, (2) the students' and teachers' understanding of scientific processes, and (3) the scientists' satisfaction with the reliability and usefulness of the data collected. A subproblem of the study also examined the relative effects of using videotapes of the scientists versus live contact with the scientists.

The students involved in the treatment group participated in botanical and zoological investigations under the direction of their teachers and university scientists. One class for each of the experimental teachers worked directly with a scientist; two to three classes were exposed only to a videotape of the scientist.

Students and teachers were pretested and posttested using the Test of Science Related Attitudes (Fraser, 1981), and the Test of Integrated Process Skills (Dillashaw & Okey, 1980). Each student and teacher also completed a questionnaire to assess their attitudes toward the investigations. Interviews with the scientists assessed their participation in the program and their evaluation of the research data received.

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Session D-2

"HOW DOES SCIENCE AND MATHEMATICS CORRELATION IN A SEVENTH GRADE PHYSICS UNIT AFFECT SELECTED SEVENTH GRADE STUDENTS' ATTITUDES TOWARD AND ACHIEVEMENT IN SCIENCE?"

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The purpose of the present study was to determine how correlating science and mathematics in a seventh grade physics unit affected selected seventh grade students' attitudes toward and achievement in science.

The students involved in the study were 108 New York City seventh graders divided into four classes. Two classes consisted of students with standardized reading and mathematics scores at least two years above grade level, while two classes consisted of students with standardized reading and mathematics scores at grade level. The students were of a middle socio-economic background, and about one-half were male and one-half, female.

The Science Attitudes Appraisal was administered to the sample in April, 1983, and again in June, 1983. The Appraisal is composed of 60 items, with a reliability (Coefficient Alpha) of 0.87.

A teacher-constructed Test of Physics Facts and Principles (New York City Board of Education) was administered to the sample in June, 1983. The instrument has a reliability (Kuder-Richardson 21) of 0.85.

Two classes, one with students who had standardized reading and mathematics scores at least two years above grade level (n = 30), and one with students who had standardized scores at grade level (n = 24), followed a science-mathematics correlation format. The remaining two classes (n = 27 for above grade level and n = 27 for at grade level) served as controls.

Correlated t-tests were used to evaluate the null hypothesis: "There is no change in selected seventh grade students' attitudes toward science when science and mathematics are correlated."

The null hypothesis was accepted for the entire Appraisal, but was rejected for _one_ of the four Appraisal scales. There was a statistically significant (.01 level) difference in favor of the correlated at grade level students _on_ the "Adoption of Scientific Attitudes" scale.

Uncorrelated t-tests were used to evaluate the null hypothesis: "There is no difference in selected seventh grade students' knowledge of specific physics facts and principles, whether or not science and mathematics were correlated."

The null hypothesis was rejected for students reading _above_ grade level, but was accepted for students reading _on_ grade level. Students reading _above_ grade level who had science and mathematics correlated scored significantly (.01 level) on the _Test of Physics Facts and Principles_ than did students reading _above_ grade level who did not have such correlation.

Session D-4

DEVELOPMENT OF A COMPUTER ANIMATED SCIENCE PROCESS SKILLS TEST

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The graphics and animation capabilities of computers offer a new dimension in science testing. Instead of presenting verbal situations or questions with accompanying pictures, computers can present simulated actions and events that are the focus of science questions. The purpose of this project was to develop a valid and reliable computer-based test of integrated process skills that employed both graphics and animation to present and pose questions about science phenomena. A pool of items was prepared to assess variable identification, hypothesis formation, operational definition, experimental design, and interpretation of data. Field trials of the computer-based test were conducted with more than 150 students in grades 9 through college level. Students completed the test at computer terminals in about 45 minutes. The results of the field trial show the test to have good reliability. Difficulty and discrimination indices are within the limits expected for tests used to assess criterion-referenced achievement. The computer animated test represents an alternative way to present science phenomena to students for classroom assessment or in research and evaluation studies.

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Session D-4

DEVELOPMENT OF A TEST OF PROCESS SKILLS FOR GRADE 3 ELEMENTARY SCHOOL PUPILS

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For some time the development of process skills has been accepted as being an important part of elementary school curricula in science and in other subjects. Unfortunately, few valid and reliable tests exist for their assessment. The few tests that are available are either specific to science in that they incorporate factual knowledge, or are more suitable for the upper grades since they assume certain levels of reading that may not have been attained in the lower grades.

The Show Your Skills test, currently under development, is designed to meet the following criteria:

1. It should test process skills taught in the first three years of schooling.
2. Its content should not be slanted towards any particular subject on the curriculum.
3. It should be capable of being administered to a class-sized group.
4. It should assume very low levels of reading ability and be structured so that it can be read aloud to the class.

Previous experience in designing achievement tests in Mathematics and Science led to the decision that the following criteria must also be met:

5. All answers must be written on the question papers since there was a very high incidence of error in recording answers on mark sense sheets.
6. The test should not last for more than one class period (i.e., a maximum of 45 minutes).
7. At least three versions of the test were necessary in order to reduce incidence of copying.

The three versions of Form 1 have been administered to 318 Jamaican students in Grade 3 classes in ten rural elementary schools. The mean of form 1 was 20.67 with a standard deviation of 6.6. A Cronbach alpha of 0.85 was obtained. Six of the items had a facility of 0.32 or less, six items had a facility of 0.75 or greater. Discrimination indices were also satisfactory.

Currently, plans are underway for testing all six versions of the test simultaneously with students of the same age in Barbados, Belize, and Jamaica.

It is hoped that the resulting tests will be a useful resource for assessing the levels of development of the process skills whether for research purposes or in the evaluation of student learning due to curriculum development.

Session D-4

CONSTRUCTION AND VALIDATION OF A PICTORIAL PHYSICS TEST AND ANALYSIS OF ITS RELATIONSHIP TO INTELLECTUAL DEVELOPMENT AND SCIENCE APTITUDE FOR JUNIOR HIGH SCHOOL STUDENTS IN TAIWAN

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The initial purpose of this study was to construct a pictorial physics test which would measure the degree to which ninth grade students understand basic physics. It was proposed that the test would be used in Taiwan to assess, through pictorial means, the degree to which a student has attained a nonsyllogistic or intuitive understanding of physics.

The pictorial instrument contained items in a stem picture and three/four choice pictures; one of which was true in relationship to the stem. Using Bloom's Taxonomy, test items were drawn from introductory junior high school physics programs in Taiwan. Five hundred forty ninth-grade subjects made up of 270 males and 270 females living in rural, suburban and urban (90 males, 90 females) areas were randomly selected for the study. Four student characteristics: IQ, science aptitude, sex, and study area were selected as independent variables. The dependent variables were the degree of the student's understanding of basic physics which was measured by the pictorial physics test, and the verbal physics test.

Results indicated that students performed better on the pictorial physics test than on the verbal physics test in the total sample and subsamples. The higher the student's IQ level or the higher the student's science aptitude level, the better was the performance on the pictorial physics test. Students from urban areas showed better performance on the pictorial physics test than those in suburban or rural areas. However, there was no significant difference between suburban students and rural students. Male students had higher physics achievement scores than did female students. The practical advantages, reliability, and validity of the pictorial physics test indicated that it provides a potentially unique and useful tool to the junior high school physics teacher in Taiwan.

Session D-5

THE INFLUENCE OF FIELD EXPERIENCES ON STAGES OF CONCERN AND ATTITUDES OF PRESERVICE TEACHERS TOWARD SCIENCE AND SCIENCE TEACHING

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The purpose of the study was to investigate whether the field experience component of an undergraduate science methods course was effective in: (1) shifting student concerns about teaching science from concerns about self to concerns about the impact of inquiry-oriented science on pupils, and (2) improving student attitudes toward science and teaching science. Age, grade point average, openmindedness, and school assignment were examined as factors which might explain some of the variance in the dependent measures.

The subject were 64 students enrolled in three sections of an undergraduate methods course at a University in Louisiana during the 1983 spring semester. Sections were randomly assigned to three schools for field experiences and students were randomly assigned to cooperating teachers. During the approximately 20 hours spent in elementary schools, students observed their cooperating teachers, interviewed children to assess developmental levels, and used discovery and inquiry strategies while teaching science lessons to small groups of children.

A one-group pretest-posttest design was used. Subjects were administered the Teacher Concerns Questionnaire (TCQ) and the Science Teaching Attitude Scales (STAS) at the beginning and end of the field experience component of the methods course. They were also administered Form E of the Rokeach Dogmatism Scale (D-Scale) as a measure of openmindedness. Posttests were administered approximately eight weeks after the pretests.

Results indicated that field experiences did not significantly change students' concerns about teaching science but significantly improved student attitudes toward science and science teaching. Openmindedness was found to be positively related to changes in attitudes toward teaching science.

Session D-5

RESULTS OF PROJECT MAFEX: HOW EFFECTIVE ARE FIELD EXPERIENCES IN SCIENCE TEACHER EDUCATION?

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This paper presents the results of Project MAFEX (Meta-Analysis of Field Experience). The project utilized standard meta-analysis techniques to synthesize the available body of research concerning preservice field experience programs. Several important questions were considered: What type of field experience programs are most and least effective? Are there common characteristics of field based programs that make them more or less effective? Do field experience programs affect students consistently in all areas? How do field experiences in science education courses compare to field experiences in other areas of study? These programs are assessed in relation to preservice teacher attitudes, achievement, delayed outcomes, and teaching behavior.

Consistent findings indicate that field experiences are generally positive experiences in general education courses, methods courses, and science methods courses. Attitudes, achievement, and teacher behavior, however, are not affected equally in all classes. In addition, duration studies of field experience indicate that few to moderate numbers of field experiences tend to have positive effects on preservice teachers. Conversely, exposure of students to many field experiences appears to dramatically diminish previous gains on desired outcomes. Other field experience factors studied include: grade level, timing, single and blocked programs, socio-economic status, etc.

Session D-5

THE CONTRIBUTION OF SCIENCE LOCUS OF CONTROL ORIENTATION TO EXPRESSIONS OF ATTITUDE TOWARD SCIENCE TEACHING

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A new construct--Science Locus of Control (SciLOC) Orientation--was examined as a predictor of attitudes toward science among 108 preservice elementary teachers. It was postulated that each person holds beliefs regarding the degree of his or her personal control in situations where decisions, actions, or other modes of performance require either the application of scientific knowledge or the employment of inductive and deductive reasoning skills associated with scientific thinking. These beliefs give rise to behaviors, including expressed attitudes, which reflect the control orientation.

Multiple regression analysis was employed to demonstrate that up to 47% of the variance in expressed attitudes toward science teaching can be explained by SciLOC orientation. Further analysis indicated that up to 24% of the variance in SciLOC orientation can be explained by differences in quantitative comprehension, gender, age, father's occupation, ethnicity, and high school size.

These results are interpreted as evidence that: (a) SciLOC orientation is a major contributor to expressed attitudes toward science teaching among preservice elementary teachers, and (b) SciLOC orientation is influenced by a variety of factors related to academic and cultural experiences. Related findings regarding the modification of control orientation through instruction are briefly presented.

Session E-1

SYMPOSIUM: LEARNING SCIENCE IN OUT-OF-SCHOOL SETTINGS

AGE, SEX AND TIME ON TASK IN MANIPULATIVE MUSEUM SETTINGS

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One hundred and thirty one visitors to the Florida State Museum were observed as they attended to a case exhibit on shells which had a removable cover. Some visitors observed the exhibit with the cover on the exhibit (N=39), others observed it with the cover off enabling them to touch and compare shell types (N=40), and a third group observed the exhibit with the cover off and with an opportunity to use a bioscope to closely examine specific shells of interest (N=52). Trend analysis indicated that: 1) Amount of time spent at the shell exhibit was positively related to the opportunity to manipulate and to closely inspect exhibited objects, regardless of age; 2) Children and early adolescents spent longer periods of time viewing the exhibit than did adults; 3) The percentage of visitors who stopped at the exhibit increased during the uncovered, manipulative conditions.

On the whole, the data here contribute to the growing mass of information suggesting that, in free-choice settings, modes of presentation which permit the manipulation of objects attract and hold attention and may well result in significant learning outcomes.

Session E-1

THE EFFECTS OF LEARNING OF SCIENCE EXHIBITS WITH ACCOMPANYING QUESTIONS

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Fifty five undergraduate education majors were randomly assigned to one of three treatment conditions as they entered the "walk-through" cave exhibit at the Florida State Museum. Subjects in Treatment I received set induction materials directing them to enter the cave, to observe the cave carefully, and finally to read the information in five case exhibits after exiting the cave. Subjects in

Treatment II observed the cave exhibit, read the information in the five case exhibits, and answered two experimenter-generated questions about each case exhibit immediately after reading the information on it. Subjects in Treatment III observed the cave exhibit, read the information in the five case exhibits, and generated two questions about each case exhibit and answered them immediately after reading the information in each exhibit.

All subjects received an immediate 20 item posttest. Seven of these items focused on observations from the "walk-through" portion of the cave exhibit. The remaining 13 items covered the information in the case exhibits. Analysis of variance indicated no significant differences between groups on the observation question. However, a significant difference was detected for the case exhibit questions ($p < .05$). Follow up analysis indicated that subjects who answered the experimenter-generated questions performed significantly better than subjects who did not answer any questions. Although no other differences were detected at the .05 level, the trend of results indicated that subjects who answered experimenter-generated questions performed better than subjects who generated their own questions. These latter subjects performed better than did subjects who read the case exhibits without answering any questions.

These data support the considerable research indicating that the insertion of questions into instructional material increases the amount learned from the materials.

Session E-1

STUDYING RECESSING AS AN ATTENTION-DIRECTING DEVICE IN A MUSEUM EXHIBIT

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This study was designed to explore the use of recessed spaces in a museum exhibit as an attention-focusing device. Ninety-nine subjects were randomly assigned to one of three treatments in which they either viewed an exhibit in which specific specimens were recessed or viewed an identical exhibit in which the same specimens were not recessed. A control group did not view an exhibit at all but received a placebo. Posttest analysis using a 3 X 2 analysis of variance revealed significant main effects. Further analysis using Scheffe' tests indicated that there were significant differences between the treatment group viewing the exhibit with recesses and the treatment group viewing the exhibit without the recesses, with the latter being more effective ($p < .05$). There were also significant differences between the treatment group viewing the exhibit with recesses and the control group, with the former scoring higher ($p < .05$). There were no significant differences, however, between the treatment group viewing the exhibit with recesses and the control group. Although recessing is frequently used by exhibit designers in science museums, its value is not supported by this study.

Session E-1

VISITOR BEHAVIOR AS A FUNCTION OF TIME IN MUSEUM

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A study was conducted at the Florida State Museum of Natural History to assess visitor behavior as a function of time in museum. A total of 60 adults (90% as part of a larger social grouping) were tracked, from the moment of entrance to the moment of exit, and every five seconds the dominant locus of their attention recorded. Five loci, plus a "Can't Tell" category, were possible: attention to exhibit; attention to setting; attention to self; attention to own social group; or attention to other visitors.

Results showed that during the first 35 minutes of a visit, locus of attention remained essentially constant with attention directed 66% of the time to exhibits, 18% to setting, and 14% to own social group. During the remaining 15 minutes of the average duration visit, attention to exhibits fell rapidly to a new plateau of about 52%, attention to other aspects of the social/physical environment rose proportionately.

These results have interesting implications, both philosophically and methodologically, for investigators interested in learning in informal education settings.

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Session E-1

LATENT EFFECTS OF FAMILY LEARNING COURSES IN SCIENCE

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Learning in the family has been considered by some one of the most crucial of all educational experiences, since it begins earliest in life, includes the learning of basic information necessary for future learning and survival, and continues throughout life (Bobbitt and Paolucci, 1976). Despite the fact that learning with family involvement has been recognized as an important part of the total educational process, very few family learnings programs in science are described in the literature (The Smithsonian Family Learning Project, 1980; Miller-Martin, 1975; Katz, 1978).

This study focuses on a single innovation that holds promise for an increase in scientific literacy in children and their parents. Staff at the University of Minnesota, with financial support from the National Science Foundation (DISE Grant #07872), developed five science courses for middle school children and their parents. According to the overview manual of the project, the courses function as experimental models focusing on parents and children learning science together.

The paper will describe a follow-up study of the family learning courses in science that was reported earlier (Gennaro et al., 1980, Gennaro and Heller, 1983, Ostlund, 1983). The study is an attempt to gain insights into these learning experiences. The triangulated study reports on the analysis of interviews of focal pairs included in a previous study one year after taking the course. It includes the results from an analysis of responses received on a questionnaire distributed to a sample of the 500 participants in the parent-child courses, one, two, or three years after taking the parent-child courses, and telephone interviews with another sample of participants.

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Session F-2

SELF-GENERATED THOUGHT AS A RESULT OF A PERSUASIVE MESSAGE AND ITS IMPLICATIONS ON THE ATTITUDES TOWARD ENERGY CONSERVATION OF PRESERVICE ELEMENTARY TEACHERS

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Recently, speech communication researchers have suggested a correction to McGuire's information processing paradigm in the form of a cognitive response approach to attitude change. The new cognitive response approach maintains that, when one listens to a persuasive communication, an attempt is made to relate the arguments presented in the communication to what one knows about the topic. Any favorable thoughts generated as a result of the persuasive communication should favorably influence the listener's attitude responses to the communication.

One-half of the subjects (N=58) that viewed a videotaped communication outlining the importance of teaching energy conservation reviewed a list of favorable arguments presented in the communication. The other subjects listed thoughts that came to mind as a result of the communication. Significant was the finding that while subjects who listed their thoughts were no more likely to exhibit a change in attitude than those that reviewed the favorable arguments presented in the communication, those subjects who listed a greater proportion of favorable thoughts were most likely to exhibit a greater change in attitude.

Session E-2

THE PROCEDURE FOR REVISING A LIKERT SCALE ASSESSING PRESERVICE TEACHERS' ATTITUDES TOWARD TEACHING SCIENCE

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The purpose of this study was to design a procedure to revise an attitude scale. Each step was implemented on a Likert instrument, A Science Attitude Scale published in School Science and Mathematics (1974).

Ten statements not adequately describing the attitude object (science teaching in the elementary school) were dropped, using the data of a three-member jury of science educators. New attitude items were written to meet Edwards' (1957) 13 criteria, to represent the four subcomponents of the attitude object and the definition of attitude, and to insure negative/positive balance. Thirteen original items and slight modifications were added to the trial pool of items. These 49 items were administered to 80 preservice elementary teachers along with a metric attitude scale and a reading attitude scale used to test validity.

Statements with an item-total correlation coefficient (adjusted) of 0.37 or less were dropped. Items having a large percent of undecided responses did not pose a problem. Ten negative and 12 positive statements withstood the tests. Only four of the original 23 items and six slightly modified ones withstood the rigor of all the tests.

When the revised scale of 22 statements was submitted to the Likert analysis, the coefficient alpha was 0.915. The item-total correlation ranged from 0.368 to 0.784.

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Session E-2

THE EFFECT OF PARTICIPATION IN AN ACTIVITY ORIENTED SCIENCE CURRICULUM DEVELOPMENT WORKSHOP ON THE ATTITUDE OF ELEMENTARY TEACHERS IN TRINIDAD AND TOBAGO

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The purpose of this study was to investigate the extent of science attitudinal change in elementary teachers in Trinidad and Tobago during an activity - oriented science curriculum development workshop. More specifically, responses to groups of items dealing with:

(1) Attitude toward Science Content

(2) Attitude toward Science Equipment

(3) Interest

(4) Antipathy

were analyzed to determine in which of these areas attitudinal changes might have occurred.

The investigation involved the administration of the Shrigley-Johnson Attitude Scale for In-service Teachers as modified by the author as a pre-test and post-test. The subjects included 35 elementary in-service teachers who participated in a ten-day workshop.

The ojectives of the workshop included:

(1) To change the teachers' negative attitude to science teaching,

(2) To expose teachers to teaching strategies involving hands-on experience.

The results indicated that all students had a positive shift in science attitude. The t-test analysis of responses showed shifts in several areas at the .001 level of significance. Comparison of the means of the responses to individual items on the pre-test and post-test revealed a positive shift on each item.

It can be concluded that the workshop had some effect in changing the teachers' negative attitude toward science teaching. Further research needs to be done to determine whether this change is long lasting.

Session E-2

IMPACT STUDY OF ENERGY EDUCATION WORKSHOPS ON THE PARTICIPANTS AND THEIR PEER TEACHERS

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The purpose of this study was to investigate the impact (one and two years after workshop participation) of two Department of Energy (DOE) summer energy education workshops conducted at the University of Maine at Orono (UMO) during the summers of 1980 and 1981 on the 67 DOE participants, and the impact of the local inservice energy education workshops, conducted by the DOE participants, on the 67 peer teachers, one selected by each DOE participant.

The sample consisted of 50 DOE participants who responded to the survey-for-participants and of 29 peer teachers who responded to the survey-for-peer-teachers. Both mail surveys were modifications of the Survey of the Current Status of Energy Education. Frequency distributions, chi-square statistic, and Spearman Rank Correlations were computed.

It was concluded that the DOE workshops at UMO had a significant effect on the DOE participants' teaching of energy education topics, on their curricular design, and on their utilization of energy education curricular materials. Also, the peer teachers increased the number of energy topics in their school curriculum after participation in the local inservice energy education workshops.

Session E-3

RESEARCH METHODS SEMINAR
LEVELS OF USE: A STRATEGY FOR ASSESSING IMPLEMENTATION

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Even casual observers of education point out that teachers frequently do not use officially adopted programs. On the other hand, science education researchers are commonly observed reporting evaluation studies of program outcomes without substantiating the assumption that the program was in fact being used in the classrooms being assessed. Strategies assessing the extent of use of programs have been lacking. The Concerns-Based Adoption Model has developed strategies for determining the nature and extent of implementation. One dimension of that model, Levels of Use (LOU), has focused specifically on the behaviors of teachers in relation to their individual implementation of an innovation. Further, LOU interviews make it possible to assess whether that use is mechanical, routine, or of a refinement nature. Science educators can use LOU in their research, curriculum implementation, consultation and the assessment of school-based programs.

Session E-4

TRIANGULATION APPROACH TO RESEARCH ON SCIENCE LEARNING IN THE SCHOOL LABORATORY

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The intended, perceived, implemented and achieved curriculum of high school biology classes in Israel was studied, using a variety of data sources and research methodologies. The intended curriculum was identified by analysis of commonly used laboratory manuals. The perceived curriculum was captured by procuring the views of teachers and students on the importance and practice of educational objectives associated with learning in the laboratory. The implemented curriculum was assessed by structured and non-structured observations as well as by analysis of students' written assignments. The achieved curriculum was assessed by analysis of a large sample of the practical laboratory matriculation examination papers. Problems and difficulties, both conceptual and managerial, were identified with special emphasis on students' misconceptions. A learning module based on the findings and aimed at enhancing students' understanding of the processes associated with planning investigations was designed and tried in a number of 12th grade classes. Examples and results as well as their educational implications are discussed.

Session E-4

USING INTERACTIVE LOGO PROCEDURES TO ENHANCE CLINICAL INTERVIEWS WITH CHILDREN

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Many efforts to assess the state of children's knowledge are confounded by the child's own ideosyncratic twists of thought and susceptability to adult suggestion. A line of research based on the clinical interview method of Jean Piaget has had success in dealing with these problems. Instead of searching for the stochastic processes underlying a population of children, the theoretical perspective of this method views child thought as inherently structured. The interview is designed to follow the spontaneous notions of the child who is solving the problem. The interview technique uses a questioning and listening strategy which strips away the interference of random or suggested answers.

The computer language Logo was developed by Seymor Papert within the Piagetian perspective of child thought. Following work that has already shown the ability of specially designed Logo procedures to reveal spontaneous thought, this study combines the clinical interview with Logo driven problems. Utilizing the turtle graphics and list processing features of Logo, a child's problem solving behavior is captured and analyzed in conjunction with the tape recorded interview.

Children's keyboard responses to push and pull force and motion problems not only make visible the ideosyncratic concepts of force and motion, but also show the child's pattern of dealing with instructive information offered in the interview. The basic problem is to make the turtle move under a Logo simulation of Newton's First Law, with and without gravity, and hit a target. The keyboard control includes rotation to the right, rotation to the left, and an impulse force. The keyboard responses of children ages 8 to 12 are recorded and analyzed according to the velocity of the turtle, turtle heading, and bearing of the target from the turtle.

Statements of children's concepts are presented with sequences of turtle motion in the context of one or more of the problems. Implications for instruction are discussed with an emphasis on how Logo procedures can be used to enhance the child's ability to understand physical laws and the teacher's ability to understand the child's mode of thought.

Session E-4

A SEMANTICS FOR INTERVIEW TRANSFORMATION

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A growing number of researchers in science education is studying how misconceptions influence science learning and science thinking. A trusted research tool for uncovering conceptual organization in the mind of a student is the clinical interview. Although interviewing procedures are reasonably well-defined, critics of interview methods still question the reproducibility of the results obtained from interview interpretation. One recent approach to inferring cognitive structure is to treat a respondent's language as knowledge claims entitled or at least produced within a knowledge structure consisting of key concepts, sets of principles, and a theoretical framework. Given the respondent's language, the task of interview interpretation becomes one of inferring the organization of concepts and principles most likely to lead to such claims (Ault, Novak and Gowin, in press). Rigorously defining any such interpretation procedure presupposes a semantic coding system for responses. Semantic coding transforms responses -- i.e., children's explanation of interview events -- into propositionally linked, symbol use categories and provides a data base for drawing conclusions about patterns of inference-making particular conceptual structures entail; i.e., the organization of meaning likely to produce observed statements. This paper presents a Novice Science Semantic (NSS), and propositional coding scheme tailored for use with explanations of interview events given by novice science learners, child or adult; describes the context which led to the construction of NSS; and offers a preliminary example of its use.

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Session E-4

ELECTRO-MECHANICAL MEASUREMENTS OF PHYSIOLOGICAL OUT-PUT IN RESPONSE TO TEST STIMULI

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Emotionality, which is a major component of test anxiety, is measured in response to both disruptive and helpful stimuli. Emotionality is the reaction of the autonomic nervous system to evaluative stress. Ten disruptive and 10 helpful testing cues that were isolated by students in previous studies serve as those stressors.

Fifty students, both male and female, who are enrolled at a university in the Southwest served as subjects. Subjects were categorized as either high test anxious (HTA) or low test anxious (LTA) by the score they achieved on a standardized psychometric scale.

Data reported consist of physiological responses (i.e., electrocardiography, galvanic skin response, and respiration) of subjects to several experimental treatments (i.e., relaxation, disruptive imagery, relaxation and helpful imagery). Results are analyzed to determine if significant differences in out-put exists for conditions as follows: among treatment for each subject and among treatments for two categories (i.e., HTA and LTA). A preliminary analysis of the data indicates that sufficient evidence exists to support the conclusion that specific testing stimuli (disruptive) which occur in science classrooms appear to elevate physiological functions for both HTA and LTA subjects. Whereas, the other specific testing stimuli (helpful) which also occur in science classrooms appear to stabilize physiological functions for both HTA and LTA subjects.

Session E-5

PAPER SET: RESEARCH AND DELIBERATION FOR SCIENCE EDUCATION RENEWAL: THE CANADIAN EXPERIENCE

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Science education has been the object of critical review in several countries of the world in recent years. This paper set describes a large scale study conducted by the Science Council of Canada into science education in elementary and secondary schools throughout Canada. This study, the first of its kind in Canada, is to be completed during 1983, and the final report issued early in 1984.

Beyond its significance to science education and to Canadians, however, the study has sought to break new ground methodologically. Following the work of Joseph Schwab, the study has been conceptualized in terms of two integrated processes: (1) deliberation into the aims and practice of science teaching in the future, a process involving not only the science education profession but others having a stake in the enterprise; (2) inquiry or research into the present (and past) aims and practices of science teaching, a process designed to inform deliberations.

The three papers which make up the set are designed to serve two objectives:

1. To describe the science education issues addressed by the study and the conclusions reached;
2. To illustrate and discuss the novel methodological approaches employed to reach these conclusions.

The first paper provides an overview of the study's strategic model called "deliberative inquiry;" the second paper describes one of the major research projects in more detail; and the third is a case study of a two-day conference in which the Science Council's research data are the subject of deliberation about future directions for science education in one Canadian province. The three papers thus deal with matters of both substance and methodology. While the substance may be of concern primarily to Canadians, the methodological issues are of significance to science education generally.

Session E-5

DELIBERATIVE INQUIRY: A MODEL FOR SCIENCE EDUCATION REVIEW

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Problems of science education practice rarely present themselves as issues which are amenable to the standard methods of science education research. They are matters which (legitimately) depend on one's perspective, one's values, and one's stake in the enterprise. Debate about new directions should therefore include persons of a variety of backgrounds and viewpoints, not simply those with formal "expertise" in science education. Yet discussion of science education policy and practice should not be uninformed "opinion swapping" either. Rigorous research into relevant questions can yield information which is useful to those who must determine policy. This paper delves into how "relevant" research questions can be generated in the context of a national study of science education, into how these were attended to in the Canadian case in order that the results could indeed be "useful" in the process of determining new directions for Canadian science education. Featured in this paper is a discussion of the roles of the various participants in deliberative inquiry, and especially those of the researchers.

Session E-5

ANALYZING SCIENCE TEXTBOOKS TO FIND "TEXTBOOK SCIENCE"

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The research group has examined 30 science textbooks widely used in primary and secondary schools across Canada. The purpose of the analysis was to identify the aims of the writers and to determine what kind of provisions they make to help students reach five categories of aims for science education in Canada: learning about the science, technology and society interaction; acquiring scientific skills and processes; learning about the nature and the history of science; and learning about the Canadian context of science and technology. Four original analysis frameworks have been designed and applied. In addition, the Laboratory Structure and Task Analysis Inventory developed by Fuhrman et al. (1978) has also been used and applied to over 1000 lab experiments. Results show that although authors claim that their textbooks attend to a wide range of aims for science education, they do not in reality provide significant opportunities for students to reach aims other than learning scientific content.

The analysis also identifies some of the messages about science, technology and society, as well as those concerning the nature and history of science which are conveyed by textbooks. These messages together constitute an image of science which we have called "textbook science." Some features of "textbook science" will be discussed.

Session E-5

WHO SPEAKS FOR WHAT AND WHY? ANALYZING POLICY DEBATE IN SCIENCE EDUCATION

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This paper is a case study of policy debate about future goals of school science programs in a Canadian province of some 2.5 million people. Those debating represent the viewpoints of science teachers and others within the educational system itself, and other legitimate stakeholders including businessmen, scientific researchers, university professors, parents, and students. Their two-day debate was stimulated by a comprehensive research report about the science education system in the province. The recorded and transcribed discourse of the debate provides the database for this study.

Central to the methodology of the research is conceptualizing from the data of different positions, and the reasons behind them, for advocating the directions school science programs should take in the future. Viewed at one level, the debate was fractious and discordant. However, this research approach searches for the legitimate policy differences behind apparant confrontations about science education, and analyzes their resolution whenever it occurs. The significance of the paper is partly methodological in that it demonstrates how conceptualization of those matters can be related directly to data, and how interpretation of the events can be justified. Further, there is a substantive significance, in that the study advances a line of research into the practice of setting directions for science education.

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Session F-1

THE EFFECTS OF REASONING, USE OF MODELS AND SEX ON POSTTEST ACHIEVEMENT IN CHEMICAL BONDING AFTER CONSTANT INSTRUCTION

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The purpose of the authors in this study was to determine the effects of reasoning, use of models during testing, and sex on posttest achievement in chemical bonding under controlled instruction. Eighty-four high school students taking chemistry were randomly assigned within their classes to models and no models groups for the posttest. Reasoning capabilities were assessed by the Piagetian Logical Operations Test (PLOT) (Staver and Gabel, 1979), prior to instruction. All students then received the same instruction on chemical bonding which included teacher demonstrations of concepts with three dimensional molecular models, interspersed teacher questions during the introduction and development of concepts, student manipulation of three-dimensional molecular models during laboratory experiments, and text reading assignments on concepts prior to their instruction in class. The posttest on molecular geometry and shape contained three sections requiring memory, application, and synthesis, respectively (Bloom, 1956). Data were analyzed by regression (Nie et al., 1975). Results indicate that reasoning accounted for a significant portion ($p < .05$) of the variance in the total score, memory score, and applicant score, but not on the synthesis score of the posttest. Use of models and sex did not account for a significant ($p < .05$) portion of the variance of total scores or any section of the posttest. The three-way interaction of reasoning, model usage, and sex accounted for a significant portion ($p < .05$) of the variance in total scores, and in the memory and application sections of the posttest. Discussion focused on the results, conclusions, and implications for science teaching.

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Session F-1

INTERACTION OF LEARNER CHARACTERISTICS WITH LEARNING FROM THREE FORMS OF THE PERIODIC TABLE AND WRITTEN TEXT

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This study was designed to explore the effects on learning of: (1) structural modifications to the periodic table; (2) the location of a periodic table within instructional materials; and (3) the presence of a two-page schema showing relationships between topics explained in the written materials and the periodic tables.

One hundred and sixty high school students were randomly assigned to one of eight treatments. A 28 item posttest (Kr-21=.72), consisting of multiple choice and constructed answer items, was designed to measure subjects' ability to use their periodic tables to obtain factual information and to solve qualitative chemistry problems. Aptitude data were also collected. For the multiple choice portion of the posttest, regression analyses revealed that, for subjects with minimal experience with the periodic table, those who received the table with added visual data performed significantly better than subjects who received either of the other two tables (df 3,93;F=2.72;$p<.05$). For subjects familiar with the periodic table, significant vocabulary X table (df 3,49;F=3.22;$p<.05$) and vocabulary X location (df 1,49;F=4.46;$p<.05$) interactions were detected. Subjects high in verbal comprehension tended to take advantage of the modified tables, while those low in verbal comprehension processed the traditional table with less information most effectively. These latter students also benefitted more from having the periodic table alongside their written materials.

Session F-1

THE ACTUAL AND PREFERRED CLASSROOM LEARNING ENVIRONMENT OF ISRAELI CHEMISTRY STUDENTS

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Two versions of the Learning Environmental Inventory (L.E.I.) (65 items, 11 scales) was administered to 29 chemistry classes (N = 1090 students) in Israel.

The first version aimed at measuring the actual classroom learning environment and the second, the preferred classroom learning environment.

Significant differences were found between the actual and preferred learnings environment (Hotelling T^2; $F_{(11, 18)} = 157.4$ $p < 0.001$).

A series of t-tests has shown significant differences on all the 11 scales of the Learning Environmental Inventory. It was found that, for example, chemistry students in Israel prefer to have a learning environment that will be more goal directed, satisfactory, organized, cohesive and less difficult, formal and competitive.

On the whole, students prefer to have a more positive learning environment in their chemistry classes. These findings could serve both high school teachers and future curriculum developers.

Session F-2

AN EXPERIMENTAL TEST OF AN EXTENDED DISCRETION LABORATORY APPROACH FOR UNIVERSITY GENERAL BIOLOGY

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This was an experiment to test in a university setting a laboratory teaching approach previously found to be productive in high school settings. The Extended Discretion (ED) approach gives the student a task, from two to five brief procedural steps, and a list of resources from which to choose. The student must exercise discretion in the use of available resources in order to complete the task. The experiment consisted of 222 students in General Biology laboratory at the University of Nebraska. One group was randomly assigned to using the ED approach for one semester compared to 247 students assigned randomly to use a laboratory approach characterized as conventional or of BSCS style. The criterion variables were 1) student scores on a multiple choice laboratory exam, 2) student scores on laboratory reports, and 3) student scores on six laboratory quizzes given during the semester.

A between groups analysis showed significant differences between groups only for the laboratory reports (<.001) and these favored the conventional approach. A between instructors analysis showed significant differences (<.001) across instructors as a whole for all three criterion variables. A treatment group by instructor interaction analysis showed significant differences only for the laboratory reports (<.01). Since the only criterion variable which showed significant differences between groups (laboratory report scores) also showed significant group by instructor interaction, further analysis was considered inappropriate. The hypothesis of no difference therefore stands unrejected for all criterion variables.

If students can perform at least as well using a learning method which is more demanding and challenging than by using another method, there is still reason to consider further the more challenging approach. If it can be shown that the ED approach does actually foster independence as well as allow students to learn biology laboratory concepts to at least the degree of a conventional approach, the ED approach may have some merit. Further experiments are necessary to test this hypothesis and at the same time control for instructor variance.

Session F-2

A STUDY OF FIELD INDEPENDENT BIASED MENTAL ABILITY TESTS IN COMMUNITY COLLEGE SCIENCE CLASSES

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Analytical skills are generally thought to be the tools of scientists. The relationship of analytical skills and their use on mental ability tests should be of concern to science educators since these tests are often used to guide the direction a student is educated. One way in which tests could be biased that has not been thoroughly investigated is the inadvertant use of items favoring one perceptual orientation over another. This study explores the effect of perceptual orientation of students in community college science classes on ability tests.

Using an analysis of variance and discriminant analysis, the results indicated that the Otis-Lennon Mental Ability Test was field independent biased (FIB).

Session F-2

CHARACTERISTICS ASSOCIATED WITH ACCEPTANCE INTO A TWO-YEAR NURSING PROGRAM

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This study is designed to gather information on the demographics, decision making style, logical reasoning characteristics, language and mathematics skills of those students who are accepted into a two-year nursing program. An initial entering group of over 100 students was tested and then followed through their first year's work at a two-year urban community college. It was then ascertained which members of this group were accepted into the two-year nursing program. Analyses were performed to discover which variables were significantly related to acceptance into the program. The data were analyzed by discriminant analysis, one-way analysis of variance, chi-square, t-test to determine the distinguishing variables which best characterize the accepted group of students. In most of the literature there is shown a direct positive correlation between reading and math ability and achievement of community college science students. Since pre-nursing students are required to take two science classes and some English classes, one might expect that these variables would be important to acceptance into the nursing program.

Results of the discriminant analysis performed on 90 students showed that their math score, writing score, and logical reasoning test score best described their group membership.

The results have important implications for high school and college counselors as well as for science and nursing departments. Students with poor math, writing and logical reasoning skills should be encouraged to seek training in fields other than nursing where these skills are required. Further, students with deficiencies should be encouraged to enroll in remedial and preliminary classes.

Session F-3

ASSESSING THE IMPLEMENTATION OF MICROCOMPUTERS

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The near exponential rise in the number of microcomputers and the concomitant failure of schools to specify guidelines for the implementation and integration into the school program suggests a need for careful examination of the current status of implementation. The purpose of the study was to investigate the nature and extent of implementation of microcomputers in a stratified random sample of schools using procedures adapted from those developed by the Concerns-Based Adoption Model. Three basic research questions were identified:

1. What were the concerns of teachers using microcomputers?
2. What was the spectrum of behaviors of teachers as they moved from non-use to refinement use of microcomputers? and
3. How is the innovation of microcomputers being operationalized in local classrooms?

The concerns data were collected using the Stages of Concerns Questionnaire. The Levels of Use data were collected using one-on-one focused interviews and Innovation Configuration data were collected using the Microcomputer Innovation Configuration Checklist developed by researchers.

The results of this study show most intense concerns to be personal and informational, with consequence concerns being least intense. Collaboration concerns were more intense than would have been expected. Teachers with more years of experience and more training showed less intense personal and informational concerns and more intense concerns with collaboration and refocusing. The Levels of Use data show that more than half of the teachers were at the mechanical level, and the Innovation Configuration data showed that most of the teachers were using microcomputers in an acceptable way.

Session F-3

THE EFFECTS OF TWO MODES OF MICROCOMPUTER INSTRUCTION ON THE KNOWLEDGE AND ATTITUDES OF SCIENCE EDUCATION STUDENTS

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The purpose of this study was to compare the effect of two types of instruction in computer programming on microcomputer knowledge and attitudes of preservice elementary school teachers.

The treatments were two levels of teaching aids that augmented the microcomputer. T_1 involved the subjects in an orientation to the hardware, the provision of a microcomputer for each subject, practice periods, reading materials, a canned instruction program and maximum human instruction and feedback. Subjects in T_2 were not provided a canned program, no formal instruction on computer programming (other than orientation to the hardware) and a teacher on call when the subject became stuck in use of the microcomputer. Twenty-four volunteers were randomly assigned to the treatment groups.

There were no significant differences in the mean scores of T_1 and T_2 on either knowledge or attitude tests at the completion of 19 hours of instruction.

The findings suggest that we may not need the added investments of teacher time and software in order to affect adequately the attitude and knowledge of preservice teachers in computer programming.

Session F-3

THE IMPACT OF MICROCOMPUTER SIMULATIONS ON THE ACHIEVEMENT AND ATTITUDE OF HIGH SCHOOL PHYSICAL SCIENCE STUDENTS

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The purpose of this study was to compare the effects of alternative ways of using microcomputer laboratory simulations on the achievement and attitudes of high school physical science students. The instructional strategies compared were pre-laboratory simulation, post-laboratory simulation and conventional laboratory instruction.

Outcome data were collected on three classes of ninth grade physical science students (N=58). Each of the classes had been randomly assigned to one of the instructional strategies. Students in each class worked on laboratory activities related to basic electrical circuits. The laboratory activities were keyed to instructional objectives which all students were working to achieve. Students in the simulation groups also interacted with microcomputer laboratory simulations either before or after related laboratory activities. The students worked on the simulations as a class with the teacher operating the microcomputer and simulation programs.

Both pre-laboratory and post-laboratory microcomputer simulation strategies resulted in higher student achievement than did conventional laboratory instruction. This difference occurred on achievement above the knowledge level. While each of the instructional strategies resulted in positive student attitudes, pre-laboratory simulation and conventional laboratory instruction produced the most positive attitudes. Microcomputer laboratory simulations strategies appear to be both effective and practical means of instruction.

Session F-4

SUMMARY OF RESEARCH IN SCIENCE EDUCATION - 1982

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The studies selected for the review were those published or reported during the year 1982. They were selected for the most part based on information in the ERIC/SMEAC data base for that year. Over 400 reports have been examined, synthesized, and organized around the following themes.

1. Student characteristics and behavior
2. Teacher characteristics and behavior
3. Instructional strategies
4. Instructional materials, technology and environments
5. Programs and curricula
6. Teacher education and supervision
7. Research and evaluation practices
8. Science education policy and practice

The research in each area will be presented in summary fashion and discussed in terms of implications and future directions.

Session E-5

REFINING THE SEX AGENDA IN SCIENCE EDUCATION FOR THE EIGHTIES

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In the last six months, several commission reports have called for increased study of mathematics, science, and computer science by all of the nation's youth. Tremendous progress has been made by women in science, yet there are still serious discrepancies. The underrepresentation of certain ethnic minorities is even more severe. Although the differentials between males and females and between whites and minorities are narrowing, both in enrollment and achievement, the problems are more subtle. Attention must be turned to the experiences that women and minority students bring with them to mathematics and science courses and the experiences that they have in such classes. It is the purpose of this symposium to examine the research from three areas -- cognitive psychology, excellence in teaching, and intervention programs -- to understand this situation more fully.

The presentation on psychological research will consider a refocused sex equity agenda which places considerable attention on experience differences between boys and girls. It will suggest a change in emphasis from a focus on general characteristics which differentiate between males and females, such as spatial ability, to specific conceptions suggested by research on problem solving.

The presentation on research on excellence in teaching takes the position that the challenge of achieving sex equity in science learning at all grade levels demands that teachers use optimum strategies that result in high achievement and learning from all students. This presentation will summarize the relevant research and identify specific approaches for preservice and inservice use of these ideas to facilitate student achievement and learning.

The presentation on evaluation research will describe the programs that have been devised over the past ten years that show how female and minority students can be assisted in preparing for science- and mathematics-based fields of study and work. Analysis of these programs and their evaluations suggests that there are a number of components that can be incorporated into the regular curriculum, while others may still have to be provided extracurricularly.

As our workforce becomes increasingly female and minority, we cannot afford to have another post-Sputnik period of science education for the elite. Fortunately, we know far more about cognition, about teaching, and about programs that work for women and minorities than we did twenty six years ago. It is our obligation as science educators to act on this knowledge.

Session G-1

A META-EVALUATION OF THE FORMATIVE EVALUATION ACTIVITIES OF A SCIENCE CURRICULUM PROJECT

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Because the literature contains few retrospective accounts of formative (as distinct from summative) curriculum evaluations, this paper portrays the comprehensive evaluation activities associated with a science curriculum project. The range of methods includes experts' responses to structured questionnaires, experts' unstructured comments, meetings of trial teachers and developers, trial students' responses to both structured and unstructured questionnaires, results of student achievement tests, and visits to trial schools by developers. A meta-evaluation of these varied activities resulted in some tentative conclusions to guide future formative evaluations. (For example, visiting trial classes appeared to be a particularly useful and economic technique, and the usefulness of formative evaluation feedback appeared to be related to its specificity.) It is hoped that the paper will prove helpful to others embarking on formative evaluations through its provision of a detailed description of evaluation procedures, its illustration of concrete examples of useful evaluation techniques, and its tentative conclusions about the relative usefulness of different techniques in guiding the rewriting of materials.

Session G-1

SCIENCE EDUCATION AND PHILOSOPHY OF SCIENCE: TWENTY-FIVE YEARS OF MUTUALLY EXCLUSIVE DEVELOPMENT

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The contemporary crisis in science education comes a mere twenty-five years after a major effort to upgrade science curricula. Given the unsuccessful impact past science teacher training programs and science curriculum development projects have had on science education, finding contemporary solutions rooted to previously employed solution strategies of past science curriculum development programs is disturbing. Notably absent among research reports which examine the crisis in science education, and among proposed solutions which accompany these reports, is the lack of considerations for how new views about the role of theories in advancing scientific knowledge have changed what characterizes scientific inquiry. The research question was to investigate why such considerations are ignored in recommendations for improving science education.

In addressing the research question, historical developments in science curriculum development during the 1950's and 1960's were compared with historical developments in philosophy of science during the same period of time. The historical assessment of developments in the two fields provided results that help to explain why existing curriculum contexts in science and why recommendations in research reports proposing solutions for science education have both ignored newer views about the role of theories in scientific inquiry.

Implications and recommendations based on considerations for the role of theories in planning and selecting science curriculum topics are discussed.

Session G-1

TEACHER AND STUDENT ROLE IN THE IMPLEMENTATION OF A NEW INQUIRY-BASED SCIENCE CURRICULUM

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The study is concerned with science curriculum reform in a small developing Asian country in which the education system is highly centralized and where science and technology education is politicised as crucial to industrial and economic growth.

The study examines the extent to which a new, guided-discovery, inquiry-based science curriculum implies a change in normative role, and role and relationships of teachers and students, and the extent to which a change in role behaviors was evident during the year immediately following implementation.

A long term, case study approach is used involving extensive observations in classrooms of five cooperating teachers. Corresponding sets of observations were undertaken at predetermined intervals during the year prior to and the year immediately following implementation of the new program. Focused interviews with key personnel in the implementation process, viz: administrators from the Ministry of Education, inservice trainers, and curriculum developers provided additional data.

The research findings indicated that, although change in teacher role and role relationships was a predetermined prescriptor to faithful implementation of the new program, there was little evidence of change in role and role relationships during the year immediately following implementation of the new program. Lack of role change appeared to be linked with teacher perceived contraints inherent in the setting that remained unaltered with the introduction of the new program.

Furthermore, it is suggested that dimensions of role and role relationships implied in the introduction of the new program were largely underestimated and unaccounted for in the teacher inservice program and in the methods used to communicate with teachers regarding role expectations in implementing the new program. Evidence also emerged to suggest that teacher role and role relationships in the science classrooms observed were congruent with prevailing cultural values and, in this sense, were culture-bound, mutually reinforcing, and thereby highly resistant to change.

THE EFFECTS OF A WRITTEN PROTOCOL MODEL ON TEACHER ACQUISITION OF EXTENDED WAIT-TIME

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The purpose of this study is to develop and validate an inexpensive, readily accessible wait-time training model. Research shows that wait-time is a part of an interdependent student-teacher interaction system and that the manipulation of this variable has measurable effects on teacher input variables, student outcome variables and acquisition variables. The acquisition of extended wait-time is and has been a major concern in teacher education.

A written protocol model was used as the training method for a group of 23 inservice teachers. The quasi-experimental non-equivalent control group was employed in order to work with naturally assembled group which is the intent of the model. The subjects taught a series of inquiry lessons, taped and analyzed the results according to procedures in the protocol.

The results indicated that teachers could significantly increase their wait-time in one session and could reach criteria (three seconds) in two sessions. In addition, the teacher-calculated wait-time did not differ significantly from the wait-time calculated with a microcomputer pause analysis apparatus. This desired effect supported the hypothesis that teachers learn and accurately calculate their own wait-time using the written protocol model.

Session G-2

OBSERVED CHANGES IN CLASSROOM BEHAVIOR UTILIZING SUPPORTIVE INTERVENTION

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The recently reported study by Swift and Gooding investigated the effects of instructional guides and wait-time feedback upon the classroom interaction of 40 middle school science teachers. The experimental nature of that study produced an artificial situation involving little personal contact between teacher-participants and the research staff. A subsample of 10 teachers cooperated in a follow-up study. After a workshop, weekly tape recordings of the participants' classes were analyzed. Discussions with the teachers were held concerning effectiveness. Since only strengths and successes were emphasized, the process was labeled supportive intervention. Over the four-week duration of the study, important changes in teacher-student interaction were observed. Teachers extended their wait-times to the three second minimum. There was an increase in student-student interaction and in length of student responses. Teachers asked greater numbers of divergent and evaluative types of questions indicative of higher levels of cognitive discourse in the classroom. Finally, the teachers responded in a highly favorable manner to the suggestions provided by members of the research team. It appears that monitoring wait-time using an electronic device accompanied by supportive intervention does provide an avenue for the improvement of teaching skills.

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Session G-2

THE INVESTIGATION OF ROLE MODELS AND WOMEN'S CHOICES OF SCIENCE-RELATED CAREERS

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Role modeling had been thought of as an important means to encourage more young women to pursue careers in science and science-related fields. This study sought to identify and relate those variables that had affected young women's career choices.

Sex role stereotyping had been found to affect young women's attitudes about their potential for success in tasks stereotyped as masculine. Role modeling had been thought to be a positive influence on enrolling in science-related fields, but had not been researched for women choosing careers in science.

A questionnaire on role modeling was administered to an intact population of 371 high school females in public and private schools. Responses were coded and analyzed using nonparametric statistical analyses. Frequencies and cross-tabulations were reported. Gamma was used to identify the amount of relationship between the existence of a role model and the quantitative variables measured by the questionnaire.

The existence of a role model had the strongest positive relationship with the respondent's having known someone in the same career that she had chosen. Having a personal knowledge of an individual in the respondent's chosen career served as a modeling function for the individual.

Session G-3

USING GENERALIZABILITY THEORY TO EXAMINE AND IMPROVE SCIENCE TESTS

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This workshop is intended to introduce science educators to the principles of generalizability theory. Psychometrics has advanced significantly in the last decade in the description of test characteristics through the marriage of classical reliability theory with analysis of variance factorial designs. Participants will be presented with the concepts of generalizability theory. They will be shown examples of its application from several large science education data sets using both knowledge and attitude tests. Procedures for computation will be presented. Participants will be able to compute and interpret generalizability coefficients from complex factorial designs.

Session G-5

APPLYING TEACHER EFFECTIVENESS FINDINGS TO PRESERVICE AND INSERVICE SCIENCE TEACHER EDUCATION

QUANTITATIVE MEASURES OF ACADEMIC LEARNING TIME AND ACTIVE TEACHING BEHAVIORS IN SCIENCE CLASSROOMS

Jane Bowyer
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QUALITATIVE ANALYSIS OF COOPERATING TEACHER/STUDENT TEACHER CONFERENCING INTERACTION

Thomas L. Russell
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CASE STUDIES OF INDIVIDUAL APPLICATIONS OF ACTIVE TEACHING BEHAVIORS TO SCIENCE INSTRUCTION

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This study assesses the potential contribution to science teacher education of two models developed in recent research on teacher effectiveness. Good's model of "direct instruction", developed from studies of mathematics teaching, describes a set of "active teaching behaviors". The construct of "academic learning time" provides a "proxy" for a direct measurement of student achievement, one that can be used on a daily basis by a classroom observer. Secondary science student teachers enrolled in a "fifth-year" preservice teacher education program and their cooperating teachers were trained in the coding of academic learning time and active teaching behaviors.

All participants were observed prior to training and at intervals after the training. Observation forms were provided to all participants, for use in their supervisory conferences, and cooperating teachers were introduced to the strategy of coaching. In addition to the quantitative data from the coding of participants over time, tape recordings of lessons and interviews are used to provide developmental portraits of responses to the training provided. The several types of data permit others to judge both the direct impact of the training and the individual strategies that emerged as cooperating and student teachers adapted the research findings to the teaching of science.

Session H-1

SYMPOSIUM: MULTIPLE APPROACHES TO CORRECTING STUDENTS' NAIVE CONCEPTIONS

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The purpose of this symposium is to provide a forum for discussing the nature of students' conceptual difficulties and the instructional issues involved in addressing these difficulties. Each presentation describes specific naive or incorrect conceptions displayed by high school and/or college students, as well as the results of instructional interventions designed to correct or modify those conceptions.

Growing Sound Intuitions About Scientific Concepts

This presentation describes instruction in specific procedures for interpreting physical concepts, and assesses how the learning of concept knowledge in procedural form affects the students' "intuitions" about situations involving these concepts.

The Role of Contradictions in Science Learning: Implications and Alternatives

This presentation characterizes how students incorporate contradictions without changing their conceptions and explores alternatives to contradiction for changing reasoner's conceptions.

Students' Misconceptions in Science How Should Curriculum Designers Respond?

This presentation focuses on how curriculum materials can be designed to respond to student misconceptions of the atomic model in chemistry and of current in electricity. Possible instructional procedures which could alter these conceptions are discussed.

Session H-2

RECOMMENDATIONS OF THE BRITISH COLUMBIA SCIENCE ASSESSMENT FOR INSERVICE EDUCATION

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Recent surveys in the United States have described an increasing trend toward shortages of qualified science teachers. Several studies have reported common deficiencies in the use of laboratory or field experiences and in teaching for developing skills in the processes of science and in higher level thinking. The British Columbia Science Assessments of 1978 and 1982 identified similar problems in this Canadian province. In 1982, deficiencies in instruction were identified through weaknesses in the performances on achievement tests by approximately 80,000 students of grades 4, 8, and 12. Questionnaires completed by 1,322 elementary teachers and 529 secondary science teachers contributed to identifying appropriate methods for providing needed inservice programs. The B.C. recommendations stressed learning how to teach science safely for improving critical thinking skills, and providing the teachers with inservice programs presented by other science teachers.

Session H-2

ELEMENTARY SCIENCE EDUCATION LIBRARY RESOURCES IN GRADUATE AND UNDERGRADUATE TEACHER EDUCATION PROGRAMS OF NEW ENGLAND

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The purpose of the study was to compare elementary science education library resources available in graduate and undergraduate teacher education institutions of New England.

A 31 item survey was sent to teacher institutions certified to prepare elementary teachers. The survey had four components: services (i.e., *ERIC*, computer search, etc.), journal holdings [science (i.e., *Science and Children*, *Science Education*, etc.) and non-science (i.e., *Reading Teacher*, *Instructor*, etc.)], resources available (i.e., elementary science textbooks, audio-visual materials, computer software, etc.), and an open-ended question about what were the major resources needed to help prepare preservice students to teach science. There was a 72% return rate.

Data were analyzed by the Frequencies and Crosstabs Subprograms of SPSSX. Fewer than 347 of the non-graduate libraries had *ERIC* microfiche available, *Dissertation Abstracts*, and computer search capabilities services. There was a significant difference between graduate and non-graduate institutions journal holdings for *Language Arts*, *Young Children*, *Journal of Research in Science Teaching*, *Science Education*, and *The Science Teacher*. The surveyed libraries had more elementary science textbooks published prior to 1980 than those published after 1980 and were severely lacking in computer software.

Session H-2

ASCERTAINING THE "DESIRED STATE" FOR A MASTER'S DEGREE PROGRAM IN SCIENCE EDUCATION

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This study provides insight into that which both decision-makers for science education policy and science teachers perceive will meet post-baccalaureate teacher training needs in the eighties and beyond.

Qualitative methods were used to gather data between 1981 and 1983 from members of the educational enterprise and those external to it who influence policy in science education. The results were summarized using a discrepancy model comparing respondent's perceptions of the existing master's degree program in science education in a southern university to their perceptions of the "desired state" for a master's degree program in science education and describing the rationales for each recommended change in the program.

In 1983, quantitative methods were used to ascertain to what degree rural, suburban, and urban elementary teachers and secondary science teachers from three school districts perceived the "desired state" master's degree program generated by the respondents in the qualitative part of the study was desirable. The quantitative data overwhelmingly supported the desirability of the theoretical "desired state" master's degree program in science education.

Session H-4

EFFECTS OF LAB INSTRUCTION EMPHASIZING PROCESS SKILLS ON ACHIEVEMENT OF COLLEGE STUDENTS HAVING DIFFERENT COGNITIVE DEVELOPMENT LEVELS

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Many laboratory exercises require integrated science process skills, but casual observation indicates that many college students lack these skills. The purpose of this experimental study was to compare students' process skill achievement before and after exposure to laboratory exercises as they are typically taught in an introductory college biology course, and to compare this achievement to that when the same lab exercises are modified to emphasize process skill activities. Measures of process skill achievement were administered at the beginning of the course, following each lab exercise involved in the experimental treatment, and at the end of the course. The relationships between process skill achievement and cognitive development and gender were also determined.

Results indicate that emphasis on process skills in the laboratory can significantly improve process skill achievement. Students with lower levels of cognitive development had a lower level of process skill achievement, but there was no difference in gain in process skill achievement across levels of cognitive development. Females on the average had a slightly lower level of cognitive development than did males, but there was no gender difference in process skill achievement overall. However, statistical interactions indicated that females at the lowest level of cognitive development scored higher on some of the process skill measures than did males at the same level of cognitive development.

In general, this study indicates that, along with gains in content achievement, process skill achievement can be improved in students at all levels of cognitive development through reasonable modifications of existing laboratory exercises in introductory college biology.

Session H-4

FACTORS RELATED TO PRESERVICE ELEMENTARY SCHOOL TEACHERS' SCIENCE PROCESS SKILLS

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Preservice elementary school teachers entering a science methods course have been found to differ widely in their command of science process skills. A study was undertaken to examine several variables suggested by literature to be related to science process skills.

Forty-five preservice elementary school teachers were tested at the beginning of their science methods courses. Data were collected on science process skills, field-dependence-independence, dogmatism, propositional logic ability, background in science, and age.

Each of the variables except age was significantly correlated to science process skills. Multiple regression analysis indicated that, after controlling for other variables, field-independence and open-mindedness significantly explained 36 percent of the variance in science process scores. The two remaining variables explained only an additional seven percent of the variance.

The data indicate that field-independent and open-minded individuals have significantly better command of process skills than do their more field-dependent and closed-minded counterparts, and that propositional logic ability and science background are not as strongly related to process skills as are the two cognitive styles.

This study supports the assertion that certain cognitive makeups are associated with ability in science, and, perhaps, reflects that the type of science to which most elementary science teachers are exposed does little to prepare them to understand or teach how science works.

Session H-4

RELATIONSHIPS BETWEEN A SCIENCE PROGRAM'S DIFFERENT IMPLEMENTATIONS AND STUDENTS' ACQUISITION OF SCIENCE PROCESSES

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Teachers implement modified variations of curricula. These divergent implementations have not been adequately defined, nor have relationships been established between altered uses and student outcomes. This research investigated these associations with 42 intermediate-level teachers who utilized Science - A Process Approach II (SAPA II).

The nature of SAPA II implementation was identified by assessing teachers with the Stages of Concern (SoC), Levels of Use (LoU) and Innovation Configuration (IC) components of the Concerns-Based Adoption Model (CBAM). The ERIE Science Process Test (ERIE) was administered to students of participating teachers to establish student science process outcomes.

CBAM and ERIE diagnostic results were compared to define: (1) associations between teachers' SAPA II CBAM traits and student science process outcomes and (2) predictability between teachers' SAPA II implementations and their concerns about the program.

The study's five conclusions are: (1) Significantly higher science process outcomes were associated with teachers who utilized introduction activities and judged student performance utilizing science process assessments; (2) Students who made decisions, manipulated materials and recorded data had significantly greater process outcomes than did their occasionally-active or passively-occupied counterparts; (3) Teachers at LoU IVA and LoU IVB had significantly higher student process outcomes than did individuals indicating LoU O-II and LoU III characteristics. LoU III teachers had significantly higher student outcomes than did LoU O-II users; (4) Insignificant relationships existed between teachers' SoC and students' science process outcomes; and (5) Little predictability existed between teachers' uses of the SAPA II curriculum and their concerns about the program.

Session H-5

THE EFFECTS OF COGNITIVE DEVELOPMENT AND DEGREE OF STRUCTURE ON ELEMENTARY STUDENTS' SCIENCE ACHIEVEMENT

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This study explored the attribute-treatment-interaction between cognitive development and degree of instructional structure in two inquiry science units. Random samples of grade four and five students were individually interviewed to assess six conservation abilities and two logical groupings. The two samples were instructed using two inquiry methods differing in degree of instructional structure. A second treatment on a different topic reversed the degree of structure to the two groups. Science achievement was measured at the end of each treatment. Analysis of test results indicated several significant cognitive development main-effects, and two significant interaction effects. No significant degree of structure results were found.

Session H-5

MONITORING THE PERFORMANCE OF GROUPS OF FORMAL AND CONCRETE COGNITIVE TENDENCY STUDENTS USING AN INTENSIVE TIME-SERIES DESIGN

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A multiple-group single-intervention intensive time-series design was used to examine the achievement of students grouped on the basis of cognitive tendency on an abstract concept, plate tectonics. Two questions were addressed: 1) How do daily achievement patterns differ between formal and concrete cognitive tendency groups when they are exposed to an abstract concept such as plate tectonics? 2) Can models be created which highlight differences between cognitive tendency groups? To answer these questions data were collected from students of one eighth-grade earth science teacher (n=133) and of one ninth-grade earth science teacher (n=103).

The analyses conducted indicate that formal cognitive tendency students outperformed concrete cognitive tendency students while learning plate tectonics. No definite trend in group achievement was present for the concrete cognitive tendency group while a strong positive trend was evident with the formal cognitive tendency group. Models which explained up to 67% of the variance observed in daily group achievement were generated. Different models were generated for each group in the study.

Session H-5

THE EFFECT OF CONCRETE AND FORMAL INSTRUCTION UPON THE REASONING OF SIXTH GRADE STUDENTS

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Several recent studies suggest that concrete learners make greater gains in student achievement and in cognitive development when receiving concrete instruction than when receiving formal instruction.

This study examined the effect of concrete and formal instruction upon reasoning and science achievement of sixth grade students.

Four of five intact classes of sixth grade students were randomly selected into two treatment groups: concrete and formal. The treatments were patterned after the operational definitions published by Schneider and Renner (1980).

Pretest and posttest measures were taken on the two dependent variables: reasoning, measured with Lawson's Classroom Test of Formal Reasoning, and science achievement, measured with seven teacher made tests covering the following units in a sixth grade general science curriculum: Chemistry, Physics, Earth Science, Cells, Plants, Animals, and Ecology. Additionally, the seven unit tests were administered later as a delayed posttest in order to investigate retention.

At the .01 level, the two treatment groups showed no pre-treatment differences on the dependent variables, reasoning and science achievement.

Comparisons of posttest means indicated superior performance of the concrete instruction group over the formal group, at the .01 level on reasoning and on science achievement.

Delayed posttest results were similar to the posttest findings but diminished in the magnitude of the differences between the concrete and formal instructional groups and were significant at the .01 level favoring the concrete instruction group.

REFERENCE

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Session I-1

PAPER SET: SECONDARY ANALYSIS RESULTS FROM THE 1981-82 NATIONAL ASSESSMENT IN SCIENCE

THE EFFECTS OF SCHOOLING ON SCIENCE ACHIEVEMENT

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Approximately 18,000 nine, thirteen, and seventeen-year-olds from nearly 700 schools were randomly selected across the country to participate in the 1981-82 national assessment in science. This assessment, supported by the National Science Foundation, was intended to monitor the status of science in this country and to provide a rich base of data for science education research. The assessment results have been presented elsewhere (Hueftle, Rakow, and Welch, 1983). The purpose of this paper set is to provide examples of the kind of research studies being conducted on the national assessment data.

The "Effects of Schooling on Science Achievement" paper investigates the relationship between the numbers of semesters of science studied in high school and science achievement. Previous research has shown that mathematics courses studied correlate highly (+.70) with math achievement and explain an additional 30% of the variance after taking into account family, home, and community background variables. The science study is a replicate of the earlier mathematics investigation.

Surprisingly, science course participation only correlates +.35 with science achievement and explains only 4% additional variance above the background variables. The study was replicated on another national random sample of 2,000 17-year-olds with similar results.

Possible reasons for the findings are discussed along with several policy implications.

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Session I-1

WOMEN IN SCIENCE: PERCEPTIONS OF SECONDARY SCHOOL STUDENTS

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The second paper addresses the topic of science as a masculine subject. Students were asked to respond to several items concerning the appropriateness and qualifications of women as scientists. This "Science Career Equity" scale was shown to be reliable, and, differences between boys and girls were investigated. Boys scores were significantly lower than girls' on the scale and on each item suggesting a 17-year-old male chauvinistic attitude. This difference was also found among 13-year-olds and in both white and nonwhites.

The implications for girls wishing to pursue science careers are discussed and future needed research is presented.

Session I-1

PREDICTORS OF SCIENCE INQUIRY KNOWLEDGE

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The third paper investigates the influence of several antecedent variables on science inquiry skill. Much of the previous research has examined the influence of specific interventions (e.g., a new curriculum, or lab vs. no lab) on inquiry skill. Little attention, however, has been paid to the antecedent variables (student characteristics and attitudes, and classroom environment) which can influence the effectiveness of the interventions.

Results indicate that students' attitudes about their science class and the number of semesters that they have studied science do correlate positively with inquiry skill, while many other background variables such as the science budget, number of science labs, and parental education have little or no correlation. The principal predictor of inquiry ability, however, is not a specific school or community variable, but rather the students' general academic ability. In multiple regression analyses, ability is associated with about 18% of the variance in inquiry skill for 17-year-olds.

Possible policy implications of these results will be discussed.

Session I-2

SPATIAL CONCEPTUAL ABILITIES OF NAVAJO STUDENTS

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The data for this study were collected at a K-12 school located on the Navajo Reservation, in Northeast Arizona.

Efforts are underway to determine if there are any ways unique to Navajo thinking and thus to the way that they might learn. Studies have shown that a consistent lag in achievement levels for Native Americans, especially after seventh grade.

At least three possible explanations for the above phenomenon are viable: (1) They are deficient in needed skills to learn school subjects; (2) They have a different pattern for learning and processing information compared to individuals in the dominant culture; and, (3) They possess world view vastly different from Americans at large.

The purpose of this investigation was to examine the spatial thinking abilities of 66 students - 22 from 6th, 20 from 8th, and 24 from 10th grades, using Piagetian-type tasks. A battery of 10 Piagetian-type tasks was administered individually to the subjects. A chi-square one sample procedure was used for significant differences between grade levels on each task, and significant differences were detected for nine of the tasks at the 0.05 level of significance.

One must conclude that the patterns for learning and processing information that Navajos possess is the same as those utilized by the dominant culture, and further investigation must be pursued to determine which factor or factors underlie the lag in achievement levels.

EFFECTS OF LABORATORY ACTIVITIES AND WRITTEN SIMULATIONS ON THE ACQUISITION OF GRAPHING SKILLS BY EIGHTH GRADE STUDENTS

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This study was conducted to assess the effects of three instructional strategies (treatments) on the graphing achievement and engagement of 101 eighth grade science students enrolled in an urban/rural middle school. One treatment group experienced a series of hands-on laboratory activities designed to teach graphing skills while another group completed written simulations that paralled the hands-on laboratories. A third group experienced a combination of both hands-on and written simulation lessons. A control group was also included in the study. Students in the control group did not receive any graphing instruction. In addition, all subjects were evaluated for their levels of cognitive development and spatial scanning ability.

The results indicate that the three instructional strategies examined are equally effective for teaching line graphing skills to eighth graders. All groups receiving graphing instruction displayed significantly higher achievement on a graphing posttest measure than did the control group, however, there were no significant differences in the achievement of the three treatment groups. Those instructional strategies involving hands-on activities resulted in significantly higher levels of engagement than did the written-simulation strategy. In addition, those students judged to be at the transitional and formal levels of cognitive development had higher graphing achievement than those at the concrete operational level.

Session I-2

COMPARING VISUAL-SPATIAL LEARNING IN ADULT MEN AND WOMEN

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Contemporary investigations indicate that men generally perform significantly better in tasks involving visual-spatial awareness than do females (Buffery and Gray, 1972; Harris, 1978; McGee, 1978). Researchers interested in this dimorphism have developed several interesting hypotheses in an attempt to explain the difference. In 1965, Stafford suggested that the phenomenon was an inheritable trait linked to the X chromosome as a recessive gene. McGlone and Kertesy (1973) found that cortical tissue maturation rate influenced the visuo-spatial capacity of the subject. Peterson (1976) revealed that estrogen-androgen hormonal levels of a subject influenced his spatial aptitude and VanLeeuwen (1978) indicated that the environmental history of the child had the greatest influence on his visual-spatial accuracy at adulthood.

Recent studies have indicated that enhancement of mental image formation and manipulation is possible in both men and women when subjects are subjected to carefully designed spatial interventions (DeBono 1976, Lord 1983). This study was conducted to see if the women who receive spatial interventions developed in spatial ability faster than the men in the intervention group.

The study was conducted on science majors at a suburban two-year college. The population was randomly divided into three groups (experimental, placebo, and control), each containing approximately the same number of men and women. All groups were given a battery of spatial perception tests (Ekstrom) at the onset of the winter semester and a second version of the battery at the conclusion of the semester. An analysis of covariance followed by a Scheffe contrast were run on the results. The statistics revealed that the experimental group significantly outperformed the non-experimental groups on the tests. In addition, when the differences between the mean scores for the females in the experimental group were statistically compared to those of the men in the experimental group, a significant difference was found.

This study then found that many women have the capacity to develop visuo-spatial aptitude and, although they may start out behind men in spatial ability, they learn quickly and often catch the males when subjected to meaningful visuo-spatial interventions.

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Session I-3

ANALYSIS OF ERRORS MADE BY STUDENTS SOLVING GENETICS PROBLEMS

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The purpose of this study was to analyze the errors made by students solving genetics problems. A sample of ten non-science undergraduate students was obtained from a private college in Northern New Jersey.

The results support prior research in the area of genetics education and show that a weak understanding of the relationship of meiosis to monohybrid and dihybrid cross problems interferes with the ability to develop meaningful solutions. Furthermore, successful algebraic manipulations do not ensure an understanding of gamete genotypes and random segregation of chromosomes is often not understood.

A PROPOSED DEVELOPMENTAL SEQUENCE FOR PROBLEM-SOLVING ABILITY IN CLASSICAL GENETICS: THE TRIAL-AND-ERROR TO DEDUCTIVE LOGIC CONTINUUM

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In an effort to overcome certain perceived shortcomings of the expert/novice (E/N) research design for the study of problem-solving, 20 subjects representing a broad range of problem-solving ability were videotaped as they solved moderately-complex genetics problems. Subjects were selected to provide maximum variability for age, sex, college major, genetics training, and performance in genetics courses. Eleven undergraduates (novices) and nine graduate students and instructors (experts) were interviewed. The successful solutions of a single sex-linked problem by these subjects were analyzed.

Subjects were found to differ in both the proportion of problems solved and in the methods used in such a manner as to suggest that problem-solving ability is a continuum and not an E/N dichotomy. Previously unreported successful novices were identified and their solutions analyzed as well. Comparison of all successful protocols revealed that trial-and-error and knowledge development/deductive logic represent not a dichotomy but the two extremes of a continuum. These observations further suggest that as a subject's problem-solving ability develops, she/he moves along this continuum through a "trial-and-error guided by knowledge development" strategy. Futher study of successful novices promises to provide new insights for a general theory of problem solving.

Session I-3

PROBLEM SOLVING PATTERNS IN INTRODUCTORY PHYSICS

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Solution patterns to introductory physics problems were investigated by factor analyzing responses of 103 high school students to a standardized physics test. Mathematics and logic tests were also used to generate additional response patterns which were then related to those generated by the physics test. Four factors were obtained for results on the physics test which accounted for approximately one-third of the variance on the test. Each subsequent item appeared as a separate factor or was viewed as a problem unrelated to others in the test. More structural unity was apparent on the results from the mathematics and logic tests. Relationships among the tests suggest that some common ability is utilized in the physics, mathematics, and logic tests. This ability appears to involve extracting relevant components from written statements and relating these in terms of operations specified in the text statement.

Session I-4

CURRICULAR GOALS FOR SCIENCE EDUCATION

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The purpose of this study was to redefine and validate science education curricular goals for grades K-12 in the 1980's. Goals were obtained through a survey of recent educational literature. The goals were then compiled into an instrument, Science Education Curricular Goals for Validation, which was mailed to 100 science educators for validation by ranking each of the goals on a 1-7 scale (with 1 being the least important and 7 being the most important). The science educators were randomly selected from the membership of the National Association for Research in Science Teaching.

Medians and ranks for each of the 17 goals were calculated and the additional goals suggested by respondents, organized with minimal editing, were reported. The results of the study indicated that, although there was some agreement on the initial 17 goals in the instrument, there was also considerable disagreement as evidenced by the suggestions from respondents of 41 additional goals. The highest goal was one dealing with the processes, concepts, principles, and generalizations of science. The lowest ranked goal was one dealing with the integration of the humanities and the sciences.

A COOPERATIVE UNIVERSITY-SCHOOL IMPLEMENTATION OF AN ELEMENTARY SCHOOL SCIENCE PROGRAM: A TEN YEAR STUDY

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This paper describes a three-year cooperative college, school NSF Project from 1973-1976 (Beisenherz, 1976), the extended continuation of the projects through the 1978-1979 school year and an examination of the current status of the project, 1982-1983.

From the data and implications presented in the paper, one can view somewhat optimistically the teaching of science in the elementary school. Successful science teaching can occur only under optimal conditions with maximal nurturing by those responsible for leadership in science instruction in the local district and school.

While organizations such as NSF can and must continue to exercise a vital role in preparing teachers to successfully implement the goals of "modern" elementary science, the local district and elementary school must assume more responsibility for the preparation of their teachers. The ultimate responsibility for improvement lies with the individual teachers who must take the initiative to improve themselves in their area(s) of responsibility. They must possess the capabilities to identify and appropriately modify a science program that matches each of their teaching styles, as well as the interests and needs of their students.

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Session I-4

PHYSICS FOR THE PHYSICISTS: A CONTEXTUAL STUDY OF CURRICULUM REVISION

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An analysis was undertaken of the perspectives of key actors involved in a revision of the physics curriculum in British Columbia between 1955 and 1965. The perspectives of the actors are examined in light of the social, educational, and scientific context of the times and in terms of the interests of the groups they represented. Data are drawn from the personal files and correspondence of key actors, from institutional archives and from interviews with committee members and other interested people. Particular attention was paid to the relative influence of advocates of a "liberal" versus a "practical" education and to the way a curriculum is adapted in moving from one social context to another. Curriculum revision was seen to take into account the interests of some groups more than others. In this particular instance, the interests of university physicists predominated. Implications for current efforts at curriculum reform are drawn.

Session J-1

RELATIONSHIPS OF ATTITUDES TOWARD SELF, FAMILY, AND CLASSROOM ENVIRONMENT WITH ATTITUDES TOWARD SCIENCE

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Several researchers have shown that student self concept, home and family environment, and classroom environment play an important role in determining student attitudes toward science. This study was designed to examine the relationships of three major categories of variables (self, family, and classroom environment) with student attitudes toward science in grades six through ten.

Approximately 4500 students from a large and socially diverse school system in central North Carolina were used in this study. The sample included four elementary schools (K-6 grades), four junior high schools (grades 7-9), and four high schools (grades 10-12). An affective instrument was administered to the students at three times during the school year. Subscales on the instrument measured student attitudes toward self, family, classroom environment and science.

Self, family, and classroom environment variables account for between 70% and 74% of the variance in attitudes toward science. Of these variables, classroom environment has the strongest relationship with attitudes toward science.

Session J-1

RELATIONSHIP BETWEEN AFFECTIVE VARIABLES AND ACHIEVEMENT IN SCIENCE FOR NINE YEAR OLDS

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The NAEP data provide for a variety of *ex post facto* empirical research. A combination of cognitive and affective items is available for several grades and ages. In this study, the purpose to identify relationships among affective variables and science achievement of elementary students utilizing valid and reliable instruments with an appropriate representative sampling of subjects. Approximately 2,000 nine-year-olds were involved in the study. Although analysis is incomplete, preliminary correlational analysis between the variables indicates significant relationships between student affective measures and student achievement.

Session J-1

VALIDATION, FIELD TEST AND ADMINISTRATION OF THE IMAGE OF SCIENCE AND SCIENTISTS SCALE IN COSTA RICA

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The purpose of this study was threefold: 1) to translate to Spanish and adapt the Image of Science and Scientists Scale (Krajkovich, 1978) to the culture of Costa Rica's secondary-school students, 2) to further validate the Image of Science and Scientists Scale, and 3) to apply the inventory to a national sample of seventh and tenth graders.

The scale was translated into Spanish and those items that appeared unfamiliar to the Costa Rican culture, as judged by a panel of five science educators, were deleted. Thirty-two new items were developed using the reactions to science and scientists by another sample of secondary and university students. A preliminary version was administered to 120 secondary students with the highest and most significant "t" values constituting the Spanish version. The six-point Likert scale used in the original instrument was retained. Twenty-eight items from the English version remained, joined by 20 new items.

The instrument was administered to 1070 seventh and tenth-graders. Analysis of variance indicates no significant differences in attitude between sexes, but significant differences did occur among various regions of the country and types of high schools.

The instrument proved to be reliable. Using Cronbach's alpha, scores of 0.90 overall and 0.80 and 0.83 for the individual parts were obtained. A reliable and valid instrument is now available to measure the attitudes toward science and scientists in Costa Rica.

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Session J-2

THE FORMATION OF ECOLOGICAL CONCEPTS AND CONCEPTUAL SYSTEMS BY UPPER ELEMENTARY STUDENTS

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SCIS students, grades 4-6, were used to investigate ecological concept formation. Researcher-designed multiple-choice and free-sort tasks were administered. Statistics included analysis of variance, Spearman Correlation, multiple regression, frequency distributions, latent partition analysis. Findings were: (1) grade and ability, not sex, influenced concept attainment and similarity of conceptual system to discipline structure; (2) sequence of concept attainment was not influenced by grade, ability, sex; (3) concept attainment was promoted by a conceptual system similar to the discipline structure; (4) sixth graders recognized life requirements, interactions via food, mineral, gas exchange, and community groups, but not attributes of higher-order concepts: producer, consumer, decomposer, environmental factors; (5) discipline experts, not students, related examples to higher-order concepts. Recommendations for K-6 curriculum were: (1) promote conceptual system similar to discipline structure, (2) base concept maps upon lower-order concepts or attributes, (3) eliminate higher-order concepts, (4) emphasize interactions of plants, animals, decayers, non-living materials, feeding relationships, and life requirements.

Session J-2

AN EXPERIMENTAL STUDY OF THE EFFECT OF SCIENCE TEACHING ON THE THIRD GRADE CHILDREN'S ABILITY TO CONCEPTUALIZE PIAGETIAN PHYSICAL CAUSALITY IN ANIMISM AND DYNAMISM

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This study examined the effect of science teaching on the third-grade child's cognitive developmental stage and on the child's concept of Piagetian physical causality.

The Concept Assessment Kit--Conservation (Goldschmidt and Bentler, 1968) was used to assess the child's general developmental stage. Clinical interviews (Laurendeau and Pinard, 1962) were used to assess the child's understanding of living (animism) and floating (dynamism). Experimental and control groups were pretested and posttested using these measures.

Over a five-week period, the experimental group received ten 30-minute lessons on animism and dynamism, while the control group received ten 30-minute lessons in the area of language arts.

The experimental group showed a gain on both animism and dynamism measures, and the control group showed a decrease in animism and a slight gain in dynamism scores.

On the measure to determine the stage of cognitive development, all but four of the subjects met the criterion on the pretest. Thus, no difference was found among the groups tested with the Concept Assessment Kit. Therefore, the results support the hypothesis that science teaching can accelerate third-grade children in their ability to understand the concepts of anamism and dynamism.

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Session J-2

THE EFFECTIVENESS OF THE PLANETARIUM IN TEACHING SELECTED SCIENCE CONCEPTS IN THE MIDDLE SCHOOL

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This study, using 135 fifth-grade students, compared three learning environments (classroom, planetarium, and classroom-planetarium combination) in learning and retaining the concepts of rotation, revolution, and phases of the moon.

The design employed was the pretest, immediate posttest, and delayed posttest. All students were initially evaluated for their cognitive level and knowledge of the astronomy concepts. Following treatment, subjects were assessed for their achievement of the astronomy concepts. Two weeks later, a delayed posttest was administered.

There was no significant difference in learning and retention of the concepts due to different treatments and gender. However, there was a significant correlation between cognitive levels of achievement. Using the cognitive scores as a covariate, females tended to achieve better with planetarium activities, while males tended to perform better in the classroom environment.

Session J-3

USING 1981-82 NATIONAL ASSESSMENT DATA TAPES FOR SCIENCE RESEARCH

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During 1981 and 1982, the Science Assessment Research Project (SARP) of the University of Minnesota, with funding from the National Science Foundation, assessed the science achievement and attitudes of 18,000 nine, thirteen, and seventeen-year-olds nation-wide. Data tapes from that project are now available to the public.

This research workshop will focus on the organization of the data tapes and the methods for analyzing the data to address specific research questions.

The data tapes consist of student responses to achievement items in the domains of content (biology, physical science, earth science, and integrated sciences), inquiry, and STS (science, technology and society) as well as attitude items measuring students' attitudes toward their science classes, science careers, and their support for science research. In addition, the tapes contain background demographic information from the students such as their general academic ability, their parents' education, the amount of time that they spend on homework or watch television, and the types of science courses that they have taken.

In addition to the student-level information, school level information, derived from a questionnaire given to the principals, is available and coded on the data tapes. This provides information about the school enrollments and budgets, science faculty and science lab facilities.

During the workshop, presenters will discuss the coding schemes used on the data tapes, methods of recoding the tapes for scoring purposes, and procedures for using the tapes with a statistics package (SPSS). In addition, some cautions will be given for consideration in using and interpreting the data.

Possible research studies arising from the data set will also be discussed as well as implications for the future role of secondary analysis of national assessment data.

Session K-1

EXAMINING THE BOUNDARIES OF LEGITIMATE SCIENTIFIC RESEARCH: ATTITUDES OF 1983 WESTINGHOUSE SCIENCE TALENT SEARCH RECIPIENTS

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One hundred and fifty-two Westinghouse Science Talent Search honor and financial award recipients were interviewed and surveyed concerning their views of the scientist's role in controversial issues. The subjects report a lack of exposure in their schooling to aspects of the scientific enterprises which deal with public sensitivities and political realities. Little time has been devoted to developing educated analyses of social constraints in areas such as recombinant DNA, nuclear engineering, etc. Yet these areas will offer many of these students career opportunities in the coming years. Profiles of subject responses have been developed by gender and field of scientific interest.

Session K-1

GIFTED SCIENCE AND MATH STUDENTS: THE ASIAN IMMIGRANTS VS. INDIGENOUS AMERICANS-A COMPARISON BETWEEN THE SEXES

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Why are so many Asian students enrolled in the Metropolitan New York's secondary school science and math enrichment programs? Why do the female Asians in these programs have such high levels of achievement? How do these Asian females compare to their Caucasian female classmates? These were the questions analyzed in a study of 208 Caucasian students and 78 Asian students enrolled in secondary math and science enrichment programs.

The results of the student indicate that the Asian students were much more oriented to their families than were the American students. The Asian students were more influenced by their families' high expectations, and in turn received more support when they made strong commitments to any academic task. The Asians were also more comfortable with competition than were the Americans.

The Asian females were found to be different in a number of ways (more technical reading, more computer literacy). The Asian females also felt that their family network would help them in the future when they were balancing a career with family obligations.

Summarizing the results of this study, we found that different socialization patterns seem to be responsible for the achievement differences between the sexes in math and science students.

Session K-1

EXPLORING FACTORS ACCOUNTING FOR SUCCESS IN HIGH SCHOOL SCIENCE AND MATH FOR GIFTED MALE AND FEMALE CAUCASIANS

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This study used quantitative and qualitative data from 209 Caucasian students from 27 public and private secondary schools in New York City in an investigation to determine which factors are responsible for the gender difference among gifted high school students in math and science research classes. We studied the effects of socialization and stereotyping with regard to specific practices, relationships and social forces as well as the values, attitudes and perceptions that influence gender difference.

Nine factors were identified that appear to contribute to the gender differences in math and science achievement: 1) attitudes towards competition; 2) expectations about supporting a family; 3) intrinsic motivations versus extrinsic with respect to career; 4) expectations about parenting; 5) values with respect to independence and attachment, freedom and caring; 6) expectations regarding sacrifice; 7) perceived costs of making it to the top; 8) negative stereotyping, and 9) freedom of movement. Our findings refute the "fear of success" to characterize the female student (Horner, 1972), but do confirm the theoretical work of Gilligan (1982) and Chodorow (1978) on the differences in moral and psychological development associated with gender. Our research supports other recent studies that find that the attitude among women students have undergone significant changes within the past decade, but the difference in achievement still persists.

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Session K-2

UNDERSTANDINGS AND MISUNDERSTANDINGS OF BIOLOGY CONCEPTS

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Research (Shepherd and Renner, 1982, and Renner, Brumby and Shepherd, 1981) with conceptualization in science has produced two essential elements: 1) a diagnostic instrument and evaluation procedure for measuring concept understanding, and 2) fundamental data about conceptualization of specific concepts in physical science (density and states of matter) and life science (photosynthesis, evolution and extinction of dinosaurs). The purpose of this research was to identify fundamental biology concepts and assess high school students' understandings and misunderstandings of these biology concepts. From numerous topics comprising all biology courses, two concepts were identified to initiate this research with conceptualization: cell and diffusion.

The subjects of the student were 57 tenth-grade biology students enrolled in representative, traditional biology classes at an urban midwestern high school. The students responded to two essay statements; one statement posing a situation which described cells and another which described diffusion. Responses of the subjects were classified as sound understanding, partial understanding, specific misunderstandings or no response.

Only 15.8% of the subjects demonstrated sound understanding of the cell--a concept fundamental and pervasive in biology. Even less, 1.8% of the sample, demonstrated sound understanding of the diffusion concept. Partial understanding of the cell and diffusion concepts were demonstrated by 28.1% and 35.7% of the students, respectively. Fully 56.1% and 62.5% of the subjects exhibited specific misunderstandings or gave no response for the cell statement and the diffusion statement, respectively. The pilot study, instrumentation, additional results and discussion are presented in the paper.

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Session K-2

CAN THE HISTORY OF SCIENCE HELP SCIENCE EDUCATORS ANTICIPATE STUDENTS' MISCONCEPTIONS?

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The purpose of this research was to determine the relationship between students' misconceptions about photosynthesis and the historical development of the photosynthesis concept.

The sample consisted of 1405 pupils in grade five, eight, eleven, and the sophomore year in college. The students were drawn from 49 schools in nine states.

The need to develop a diagnostic instrument capable of detecting the misconceptions that students hold about how plants make food ultimately led to the construction of the Photosynthesis Concept Test (PCT). The items were designed to generate data similar to that obtained in a clinical interview. The items also reflect the history of the photosynthesis concept.

Three patterns emerge from the analysis of students' responses on the PCT. 1) Younger students are more likely to hold concepts of photosynthesis which were previously accepted by "scientists" but have now been discarded or greatly modified. 2) Societal practices tend to encourage students to hold outdated concepts of photosynthesis. 3) Students at all the grade levels studied may hold misconceptions about photosynthesis which are similar to those which occurred and are documented in the history of science.

The results of this research, when interpreted from an Ausubelian perspective, imply that students often lack the relevant concepts necessary to link the new knowledge they encounter in classroom lessons about photosynthesis to their existing cognitive structure in a meaningful way. Such deficiencies thwart development of a more sophisticated concept of photosynthesis and may reduce many potentially meaningful lessons to exercises in rote learnings. The history of science can be used to predict misconceptions some students hold about photosynthesis. Such information should be of immediate value to the classroom teacher who can plan instructional experiences to modify students' invalid and inappropriate subsuming concepts and increase the probability of meaningful learnings.

Session K-2

MODE OF ATTENDING TO SCIENTIFIC INFORMATION BY STUDENTS WHO STUDY BIOLOGY FOR MATRICULATION EXAMS AT A LOW LEVEL

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High school biology curriculum in Israel emphasizes biological content based on concepts, principles, theories and instructional mode, which are meant to help students acquire inquiry skills. This curriculum is meant to have an impact on the mode students relate to scientific information, thus on their cognitive style. Cognitive style preference was used in this study in order to identify high school biology students' characteristics. The reason for choosing this specific dimension is based on researchers' findings, which indicated a correlation between patterns of preferences and other variables, such as content and structure of learning material, and learners' personal characteristics. These variables are known to be relevant to the learning process.

The identification of students' patterns of relating to scientific information was performed in this study through the analyses of students' answers to an achievement test in biology.

Students' answers were grouped into three categories: recall, application and principle.

The study goals were:

1. To describe students' patterns of relating to scientific information based on cognitive style preferences, as was found in students' answers.
2. To compare students' cognitive preferences with those of their teachers, and to find out if there are differences between high and low achievers in biology and mathematics.
3. To investigate if there is a relationship between students' gender and their cognitive preferences.
4. To investigate students' cognitive preferences in relation to achievement test questions, which were classified accoring to their cognitive level and biological level of organization.

5. To analyze students' biological content accuracy of their answers in relation to cognitive preferences, and to compare between low and high achievers.

In this study, 150 students from 12th grade participated, and chose to study biology at a two learning unit which represents a low academic level. Students' answers were analyzed by a special key, which was developed for this study. This key was used in pilot studies for content, validity and reliability. The analysis of students' answers was done in two steps:

1. Identification of patterns of preferences. The classification of students' answers into the three categories (recall, application and principles) was done by relating only to the formulation of students' replies without considering the validity of the biological content or their relevance to the exposed problem.

2. Identification of patterns of answers for their biological accuracy. The information which was included in students' answers was classified both on the basis of their formulation, as well as on their content. Following the categorization into the three preferences, an additional analysis was made for the biological information accuracy.

Data collected were treated by performing t-tests and two-way analysis of variance, regarding the independent variables investigated in this study (gender, low and high achievers in mathematics and biology, cognitive level of test questions and their biological level of organization).

The findings of this study stress the importance of identifying patterns of students' relation to scientific information. This process of identification can serve as a basis for developing specific instructional initiatives, in order to improve students' achievements.

Session K-4

SIGNIFICANT DIFFERENCES: ALL SCIENCE TEACHERS VS. TEACHERS IN EXEMPLARY PROGRAMS

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In 1979, Iris Weiss, of the Research Triangle Institute, conducted a nation-wide, random, stratified sampling of science teachers. Her rather extensive questionnaire asked about a variety of teacher characteristics and feelings.

While it is always interesting and useful to know about teachers in general, of considerably more interest to teacher educators are the characteristics of outstanding teachers. With the advent of the NSTA Search for Excellence In Science Education, characteristics of large number of such teachers became known.

For 1982, 231 teachers in fifty programs most closely meeting criteria published by Project Synthesis in 1981 and named as exemplary by NSTA and the Project Synthesis researchers were surveyed with the same Weiss instrument. Additional questions were asked as well. In the 1983 research, teachers from thirty additional exemplary programs are being surveyed.

The 1982 data indicate clear and distinct differences between science teachers in exemplary programs and science teachers in general. These differences favor age, experience, more education in science and teaching, positive attitude, and a penchant for personal curriculum development. Much of the data on these teachers in exemplary programs has relevance to college science teaching, teacher education, curriculum development, and future research efforts.

Session K-4

CREATIONISM VS. EVOLUTION: A STUDY OF THE OPINIONS OF GEORGIA SCIENCE TEACHERS

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The purpose of this study was to survey Georgia science teachers for opinions about teaching creationism, to analyze these opinions in terms of other attitudinal and biographic variables.

The study used a stratified sample from four types of communities. Science teachers in 62 randomly selected public high schools were mailed a questionnaire on creationism and evolution. Frequencies and chi-square analyses were used to characterize teachers by attitude toward creationism and opinions in the areas studied.

Of 128 teachers responding, 97% were familiar with creationism, 30% approved of teaching it, and 28% were teaching it. Personal conviction was the primary reason for including it. Liberality in religious philosophy and familiarity with creationist literature were significant influences on teachers' attitudes toward creationism in the science classroom.

Teachers who subscribe to a liberal religious viewpoint and who are familiar with creationist literature and philosophy are more likely to disapprove of creationism. This survey reveals little enthusiasm for creationism, even among those teachers reporting a fundamentalist background. Nevertheless, science teachers have not raised serious objections to the inclusion of creationism in science courses, and many are reluctant to enter the controversy or refuse to teach it if required.

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